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EXPLORATION OF THE OPTIMIZATION PATH OF ALGORITHMIC DECISION-MAKING FROM THE PERSPECTIVE OF PUBLIC SERVICE EQUALIZATION: BASED ON THE SURVEY EXPERIENCE OF THE TOURISM BOOM IN NORTHEAST CHINA DURING THE SPRING FESTIVAL

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Abstract: Currently, the reform of the digital administration is imminent. Although traditional decision-making regulation policies can solve most social public problems, it is difficult to achieve the unity of timeliness and accuracy. Algorithmic decision-making is a process of analyzing, processing, and predicting data through computer algorithms to assist humans in making decisions. The rational use of algorithms can improve decision-making efficiency, reduce labor costs, and lower the risk of misjudgment. This paper conducts a multi-dimensional analysis of the internal logical relationship between public service equalization and algorithmic decision-making, continuously adjusts and optimizes the algorithm model, and explores algorithm applications and solutions that are beneficial to the development of public undertakings, thereby optimizing resource allocation. By applying algorithmic decision-making to public service fields such as intelligent transportation systems, medical resource allocation, educational resource optimization, public safety monitoring, social welfare policy formulation, and disaster emergency response, the quality of public services can be improved, the sustainable development of various social fields can be promoted, and the continuous improvement of the lives of the broad masses of the people can be achieved.
Keywords: Public service; Algorithmic decision-making; Optimization path; Resource allocation

1 INTRODUCTION

The report of the 20th National Congress administrations: "Improve the basic public service system, raise the level of public services, enhance their balance and accessibility, and make solid progress in promoting common prosperity." Public service equalization is an important manifestation of the core socialist values and is of great significance for promoting social fairness, enhancing people's well-being, and achieving common prosperity. During the Spring Festival in 2024, the tourism heat in Northeast China remained high. As of February 17th, the hotel bookings in Harbin on the Qunar platform during the Spring Festival increased by three times year-on-year, and the lingering popularity of "Erbin" drove the hotel bookings in Changchun, Jilin Province, Shenyang, Liaoning Province, and other places to increase by more than four times [1]. Moreover, events such as the ticket refund of the Ice and Snow World, the extortion of the chartered car of Fu Yuanhui, and the cancellation of the "Dragon and Phoenix Flying Together" performance in Laobeishi during the Spring Festival travel period also prove the importance of rationally using algorithmic decision-making to prevent public relations crises. Algorithmic decision-making can effectively improve service efficiency and decision-making accuracy in the process of promoting public service equalization, and plays a crucial role in building a harmonious society, promoting economic development, and safeguarding people's rights and interests.

2 PUBLIC SERVICE EQUALISATION AND ALGORITHMIC DECISION MAKING: THEORETICAL CONNOTATION AND RATIONALE CONNECTION

The pursuit of public service equalisation and the implementation of algorithmic decision-making both aim to better meet public demand and improve the quality and efficiency of public services. The impact of public service equalisation on algorithmic decision-making is comprehensive and far-reaching, and its logical relationship is shown in Figure 1. public service equalisation makes algorithmic decision-making more ethically just and humane. Algorithmic procedures for decision-making using big data also provide accuracy and objectivity guarantees for public services.

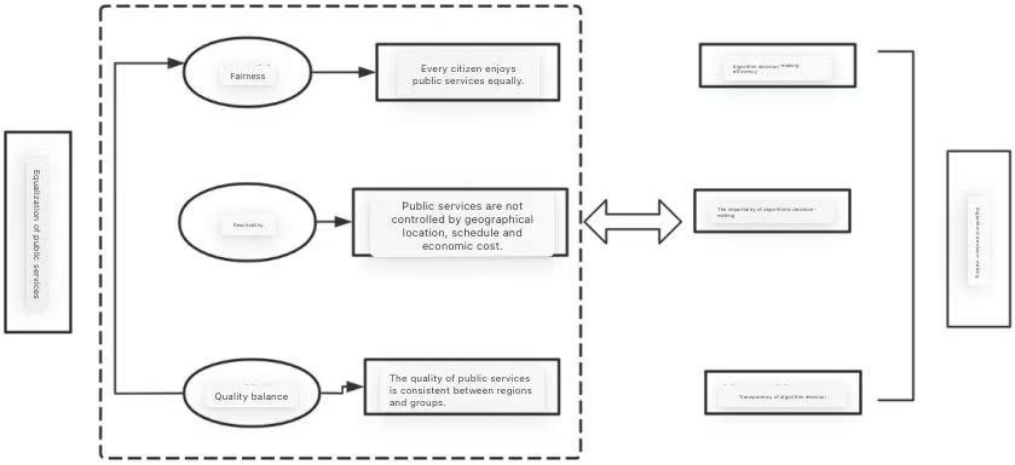

Figure 1 The Logical Connection Between Equalization of Public Services and Algorithmic Decision-Making

2.1 Public service equalisation and the internal characteristics of algorithmic decision-making

Equalisation of public services refers to the right to ensure that all citizens have equal access to basic public services in the area of public services, regardless of any non-economic factors such as gender, race, religious beliefs, etc. Equalisation of public services has the principle of universality: it requires that the scope of public services be broad, ensuring that all citizens have access to the necessary public services, including but not limited to education, health care, social security, etc.; equalisation of public services has the principle of fairness: it emphasises that the prerequisites of public services are equality and fairness, and that it avoids any form of prejudice and discrimination, ensuring that every citizen has access under equal conditions to Public services; Equalisation of public services has the principle of accessibility: it is required that the geographical location, time schedule and economic cost of providing public services should be convenient for the public to access, and there should be no insurmountable barriers. Equalisation of public services has the principle of balanced quality: the quality of public services should be balanced and consistent regardless of geographic location or among groups, and there should be no major differences; equalisation of public services has the principle of sustainability: the provision of public services is a long-term planning and arrangement of China's public utilities, and should ensure the continuity and stability of the services, taking into account the unity of economic and social benefits. These principles together constitute the theoretical basis for the equalisation of public services, which is of great significance for administration decision-making and the formulation of other public policies.

Algorithmic decision-making is a decision-support tool based on data and advanced computing technology, and is a technical means of automatically executing decisions through data collection, collation, and analysis. Algorithmic decision-making is data-driven: algorithmic decision-making relies on massive data resources, and provides scientific decision-making through in-depth excavation and analysis of the correlation and regularity between data; algorithmic decision-making has automated execution capability: people set up the parameters and decision-making model before decision-making, and algorithmic decision-making can quickly respond to the data received and automatically execute the decision-making task; algorithmic decision-making has adaptive and learning capabilities: it can constantly iterate, self-optimize, and automatically execute decision-making tasks; algorithmic decision-making is adaptive and learning capable. Algorithmic decision-making has adaptability and learning ability: it is able to continuously iterate and optimise itself, and update a large amount of database information in a timely manner to improve decision-making accuracy; algorithmic decision-making has objectivity and consistency: it avoids human subjective factors from influencing the decision-making, and reduces the interference of human factors, so as to ensure fairness and impartiality. Decision-making results can, to a certain extent, maintain social justice.

The equalisation of public services makes the public get a sense of belonging, greatly improves the public's sense of ownership, makes them better participate in social life, and provides a data source for algorithmic decision-making. On the other hand, algorithmic decision-making, with its unique advantages, makes it a powerful tool to improve the efficiency and quality of public services, and shows great potential for application in the field of public services.

(ii) Analysis of the rationale for the impact of public service equalisation on algorithmic decision-making

In today's society, public service equalisation has become an important indicator of social justice and progress in a country or region.With the rapid development of science and technology, algorithmic decision-making has gradually become a powerful tool in the field of public services.

Equalisation of public services requires that the administration should ensure that all citizens enjoy equal rights and services when providing public services. This requirement provides a clear goal and direction for algorithmic decision-making.For example, on the occasion of the Chinese New Year tourism fever in the three northeastern

provinces in early 2024, when many tourists need public services while travelling, the algorithm can analyse the demand data of each tourist and develop a tailor-made solution for them, while ensuring that it is timely and effective.This in turn enables the optimal allocation of public resources and personalised services.
The equalisation of public services requires that the administration should fully consider the differences and characteristics between different regions and groups when providing public services.Algorithmic decision-making can reveal these differences and characteristics by analysing a large amount of data, providing the administration with a scientific basis for decision-making[2]. The equalisation of public services also emphasises the care and protection of vulnerable groups.Algorithmic decision-making can identify and analyse the characteristics and needs of vulnerable groups and provide them with more accurate and effective services.Based on this, algorithmic decision-making can not only coordinate inter-regional development and narrow the gap between cities, but also pay timely attention to the relevant interests and needs of different groups in society.It is conducive to common development and advances the realisation of social equity.

3 REALISTIC CHALLENGES FACING ALGORITHMIC DECISION MAKING IN PRACTICE FROM THE PERSPECTIVE OF PUBLIC SERVICE EQUALISATION

In the pursuit of public service equalisation, algorithmic decision-making, as an emerging tool, has gradually come into the public eye and is widely used in various fields of public services.
However, a series of problems and challenges inevitably exist while algorithmic decision-making is becoming increasingly convenient. In general, algorithmic decision-making faces the challenges of data bias, privacy protection, and morality and ethics in the perspective of public service equalisation.

3.1 Limitations in the Application of Visualisation Techniques in the Algorithmic Decision-Making Process

In the field of algorithmic decision making, the application and development of visualisation techniques are crucial.
The multidimensionality and complexity of data pose great challenges to the development of algorithmic decision-making visualisation [3]. When dealing with large-scale datasets, especially high-dimensional data, it is difficult for traditional visualisation methods to show the full picture of the data to the public. For example, it is difficult to show data in ten-dimensional space in a two-dimensional plane with existing technical means. In addition, the complex logic and iterative processes within algorithms, such as the training and optimisation of neural networks, are difficult to understand for non-specialists.
Although existing technology for visualisation can reveal the behaviour of algorithms and the process of decision making to a certain extent, there are still many advanced algorithms and complex models whose internal mechanisms are difficult to visualise in a way that is understandable to the general public [4].
The public cannot observe the complete data and will be sceptical about algorithmic data decisions.The application of visualisation techniques in algorithmic decision-making is also limited by the cognitive ability and acceptance of users.Public service equalisation covers a wide range of areas, and the public in many remote areas, due to the backwardness of education, will find it more difficult to accept the so-called ‘large amount of objective data’ for decision-making about their own practical interests under the premise of a low degree of visualisation.

3.2 The Public is Algorithmically Biased and More Concerned about Data Privacy

In the wave of digitisation, algorithmic bias stems from bias in datasets, flaws in model design, and improper manipulation in the training process.
It leads to algorithms showing unfair tendency in handling specific tasks. As a result, it is likely to exacerbate social inequality under the social premise of equalisation of public services. Algorithmic bias manifests itself in the form of poor feature selection: when constructing a predictive model, the selection of features that have low correlation with the target variable or are biased may lead to algorithmic decisions that are biased in favour of a specific group of people. The rest of the general public who are not biased will become dissatisfied [5].
Whereas the administration under the public service equalisation perspective has to consider the interests of all the public as much as possible, so the public will develop algorithmic bias. In some specific cases, the algorithm's decision-making results will affect subsequent data collection and processing, creating a feedback loop that further exacerbates the problem of algorithmic decision-making bias.
Meanwhile, data privacy is also a public concern.In the digital information age, the collection and use of personal data has become increasingly generalised, with the attendant risk of privacy leakage and abuse. The public is concerned that unauthorised access to personal data by third parties for commercial marketing, credit scoring, etc. will seriously affect their normal work and life. The equalisation of public services requires the widening of public service areas and the provision of practical guarantees for the public at large, so the issue of data privacy is a great challenge to the development of algorithmic decision-making.

3.3 The Problem of Defining Ethical Responsibility in the Algorithmic Decision-Making Process

In the process of algorithmic decision-making, the problem of defining ethical responsibility is a complex and multidimensional issue, which involves the majority of users and the public [6].

Algorithmic decision-making process mainly relies on a large amount of information data, in which the definition of the responsible subject is vague. Algorithmic decision-making is sometimes regarded as a 'black box', and it is difficult for outsiders to understand its internal logic and decision-making process, and it is difficult to trace the specific reasons for the decision-making results. During the hot period of travelling in the Northeast, some users reported that they spent different amounts on taxis for the same distance. This is due to the algorithm providing different prices for different users based on their purchase history, search history and other data.

This kind of price discrimination affects the travel satisfaction of many tourists, at this time, whether the algorithm developers and travel platforms should bear the corresponding ethical responsibility. The frequent occurrence of such problems requires algorithm developers to take into account not only efficiency and profit, but also social responsibility and ethics when designing and implementing algorithmic decisions.

4 REALISATION PATH OF OPTIMISING ALGORITHMIC DECISION MAKING UNDER THE PERSPECTIVE OF PUBLIC SERVICE EQUALISATION

4.1 Strengthening Transparent Sharing and Enhancing the Fairness of Decision-Making in Administration Governance Algorithms

Fairness and impartiality is the core of value in the administration governance decision-making system, and fair and impartial decision-making is the common pursuit of citizens and also reflects the credibility of administration governance. The intervention of artificial intelligence algorithms makes decision-making fluctuate, and the fair value of administration governance decision-making is subject to certain impact, bringing administration governance algorithmic decision-making into the dilemma of how to achieve fairness. In the scenario of algorithmic embeddedness the responsible body is vague, the responsible body of traditional algorithmic decision-making is often the public organisation and individual who realises the action, while the algorithmic procedure composed of data is difficult to clarify the specific responsible body.

Take Harbin Ice and Snow World as an example, during the Spring Festival, the number of tourists in Harbin Ice and Snow World surged, and how to reasonably allocate resources to ensure the tourists' travelling experience has become a major challenge for scenic area managers[7]. To this end, the scenic spot introduced an AI-based passenger flow prediction and scheduling system, which analyzes historical and real-time data to predict the flow of visitors in the next few days, so as to rationally arrange various resources, such as ticket windows, tour guides, and catering services. In order to ensure the fairness of the algorithmic decision-making, the system adopts a multivariate data fusion method, which not only takes into account the objective factors such as historical passenger flow, weather, holidays, etc., but also takes into account the subjective factors such as tourists' age, gender, and travelling preferences. In this way, the system can predict passenger flow more accurately and avoid prediction bias caused by a single factor, thus ensuring a fair distribution of resources.

The system also introduces a dynamic adjustment mechanism, i.e., it adjusts resource allocation in real time according to changes in real-time data, which avoids wastage or shortage of resources due to prediction bias, and ensures that every tourist can enjoy a fair tourism experience.

There is objectivity in the setting of the initial procedure, which is integrated with the subjective views and values of the procedure setter, and there are potential uncertainties. This poses a new challenge to the transparency of algorithmic decision-making, and administrations should disclose the decision-making logic and rationale of algorithms so that the public can understand how the algorithms work and how they influence decisions. Algorithmic decision-making is different from e-administration in some aspects. While e-administration assists the administration in decision-making, algorithmic decision-making can meet the requirements of certain important outcomes without human involvement. Therefore, algorithmic decision-making can only be persuasive if the information is transparent, and can help the administration to make decisions, prevent public relations crises and optimise the allocation of resources.

4.2 Overseeing Governance Responsibilities and Promoting the Standardisation of Algorithmic Decision-Making in administration Governance

Strengthen the testing and vetting mechanisms before algorithmic decision-making is applied. Introducing a public process, in which the public does not specifically understand how algorithms are applied to public services before decisions are formally made, the process retains the public's right to know, improves the openness of algorithmic applications, actively listens to public suggestions, and understands the nature of the emergence of differing views, so as to understand the public's needs and to strengthen algorithmic decision-making systems.

Taking Changchun Jingyuetan Ski Resort as an example, the number of visitors to the ski resort surged during the Chinese New Year, and in order to reasonably allocate resources and ensure the tourists' travel experience, the ski resort introduced an AI-based passenger flow prediction and scheduling system, which predicts the passenger flow in the coming days by analysing the historical and real-time data, so as to reasonably arrange the various resources, such as the ski equipment rentals, catering services, and ski coaches. The system adopts a standardised data collection and

processing process to ensure the accuracy, completeness and consistency of the data. For example, the passenger flow data collected by the system includes not only historical data, but also real-time data, such as weather, holidays, special events and other influencing factors, to ensure the standardisation of the forecast data; and validated algorithmic models, such as time-series analysis, machine learning, etc., to ensure the accuracy and stability of the forecast. In addition, the system regularly calibrates and optimises the algorithmic models to ensure their adaptability. The standardisation of the decision-making process is essential, including data collection, data processing, model prediction, decision making, and decision execution. For example, after predicting the passenger flow, the system will reasonably arrange resources such as ski equipment rental, catering services, ski instructors, etc. according to the prediction results to ensure that every visitor can enjoy a high-quality tourism experience[6]. Based on this, Changchun Jingyuetan continuously optimised its algorithmic decision-making during the Spring Festival to improve visitors' experience and win a good reputation.

It can be seen that a positive algorithmic impact assessment system can play an important influence in enhancing algorithmic transparency, balancing the public's disadvantaged position in algorithmic decision-making, and effectively optimising the allocation of resources to ensure the efficiency of administration governance algorithmic decision-making efficiency, the scientific content, and the precision of the decision-making method.

4.3 Improve the Legal System to Give Legitimacy to the administration's Governance of Algorithmic Decision-Making

The premise and foundation for the administration to carry out algorithmic decision-making security governance is to have the guidance of sound regulations and policies, the current legal provisions on algorithmic decision-making in China are relatively weak, and the relevant policies are lacking in systematicity, which places higher requirements on the program setter and algorithmic decision selector in terms of ethics. Algorithmic decision-making and other digital technologies empowering the field of basic public governance contribute to the convenience of public governance decision-making, while influencing the supply of basic public services, effectively optimising the allocation of public resources, and realising the equalisation of public services.

In addition, attention should be paid to the regulation of data security to prevent the leakage of relevant information. Formulate reasonable data division requirements, categorise data well, keep important data and core data confidential, and protect the interests of the administration, enterprises and individuals. General data should also be handled carefully, so as to be responsible for the country, enterprises and individuals [8].

4.4 Promote Deep Learning and Develop Innovative Algorithmic Decision-Making for administration Governance

Algorithmic decision-making is a comprehensive consideration of many complex elements to obtain a single objective result, and the result obtained will become an important factor affecting social governance, so it is of concern to the whole society. It is a huge but very important process, and deep learning systems must be strengthened in the face of system inefficiencies and the need for personalised services. Through technological development and advancement, complex data is analysed and reliable and relevant conclusions are drawn, so that resources from various fields can be combined to uncover minute information that has been overlooked and missed, or to eliminate non-essential factors from interfering. Algorithmic systems of deep learning can replicate existing successes while also reducing labour costs and achieving better results than human decision-making.

Innovation is always the development of things can not be separated from the law of development, there is no innovative algorithmic decision-making will always stop in front. Follow up the objective changes in social development, seek innovative paths, collect public opinions and suggestions on algorithmic decision-making through multivariate decision-making, establish feedback and improvement mechanisms and other innovative ways, and continuously optimise and improve algorithmic decision-making in order to achieve a reasonable allocation of social public resources.

5 CONCLUSION AND DISCUSSION

The optimisation of algorithmic decision-making under the perspective of public service equalisation is a complex and long-term process. We will continue to move forward in this great cause, and in the face of the great background of digital information technology, we will also keep abreast of the times, not forgetting the past, absorbing the past and facing the future. Taking the application of algorithmic decision-making in the Spring Festival tourism in the three northeastern provinces as an example, we will incorporate the principle of fairness, pay attention to the regulations of ethics and morality, and ensure the privacy of data, so as to continuously improve the outstanding utility of algorithmic decision-making in practice. In order to achieve the importance of utilising algorithmic decision-making to avoid harm and to continuously regulate and evaluate the effects of algorithmic decision-making, so as to achieve the equalisation of public services, promote social justice, and enhance the well-being of people's livelihoods.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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SITUATION AWARENESS THEORY MODEL FOR URBAN THEFT CRIME

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Abstract: Under the new security situation, the problem of urban theft and crime is becoming increasingly prominent, posing a serious threat to social security and stability. The traditional crime governance model has limitations in post investigation and passive defense, making it difficult to achieve early warning and active intervention in crime. In view of this, by constructing a theoretical model of urban theft crime situational awareness based on big data and artificial intelligence, and leveraging the role of public safety intelligence as a "prophet, first mover, and first mover", we can assist in risk identification and monitoring under the background of "big security", promote the forward movement of risk warning "gateway", and provide solid theoretical support for establishing a modern public safety prevention and governance system that is globally linked and three-dimensional efficient. This is of great significance for promoting the intelligent and precise development of urban security and governance.
Keywords: Urban theft crime; Situational awareness; Data mining

1 INTRODUCTION

In the context of rapid urbanization, the problem of urban theft has become increasingly prominent and has become an important factor affecting social security and stability[1]. With the rapid development of information technology, especially the widespread application of big data and artificial intelligence, unprecedented opportunities have been provided for urban crime governance[2]. However, how to effectively utilize these advanced technologies to achieve precise perception and efficient response to urban theft crime is still an important issue that urgently needs to be addressed.

The traditional crime governance model often relies on post investigation and passive defense, making it difficult to achieve early warning and active intervention in crime[3-5]. In addition, urban theft crimes are showing a trend of diversification, concealment, and intelligence, making traditional governance methods increasingly inadequate[6]. Therefore, building a theoretical model that can perceive the real-time and dynamic situation of urban theft crimes has become the key to improving the efficiency of crime governance and ensuring urban safety[7].

This study aims to propose a theoretical model for urban theft crime situational awareness based on big data and artificial intelligence[8]. This model will reveal the spatiotemporal distribution patterns, modus operandi characteristics, potential high-risk areas, and victim groups of urban theft crimes through in-depth mining and analysis of relevant data[9-11]. It will provide scientific decision support for public security departments and achieve precise prevention and efficient crackdown on crimes.

The significance of this study lies in, on the one hand, promoting the development of urban crime governance towards intelligence and precision through the construction and application of theoretical models; On the other hand, it provides new ideas and methods for academic research and practical exploration in related fields, promoting the continuous improvement of urban safety and governance systems.

In summary, this study will delve into the construction and application of a theoretical model for urban theft crime situational awareness, in order to contribute new wisdom and strength to urban crime governance.

2 OVERALL STRUCTURE OF THEORETICAL MODEL

The theoretical model of urban theft crime situational awareness is a typical complex system, based on system science theory and intelligence science theory, supported by big data technology and artificial intelligence technology, and constructed by drawing on existing intelligence process models and intelligence perception frameworks. This model decomposes urban theft crime situation perception into four modules: theft crime data perception, theft crime intelligence characterization, theft crime situation perception, and theft crime intelligence response, as well as intelligence functions such as data acquisition, data parsing, data fusion, intelligence perception, intelligence characterization, situation perception, situation understanding, situation prediction, monitoring and warning, decision response, and post evaluation. The specific content of each module and function of the model is shown in Table 1.

Table 1 Analysis of the Theoretical Model of Urban Theft Crime Situation Perception

Perception Process	Specific Content	Intelligence Function	Specific Content

Theft crime data-aware	The perception of theft crime data aims to perceive and extract public safety and criminal intelligence data, including three intelligence functions (data acquisition, data parsing, data fusion) and two intelligence tasks (environmental data extraction, multi-source data fusion).	Data Acquisition	Comprehensively perceive and extract criminal intelligence data in the urban security environment.
		Data Analysis	Clean the collected raw criminal intelligence data and achieve data standardization.
		Data Fusion	Adopting an aggregation management mode, integrating heterogeneous data modalities, promoting the fusion of multi-source criminal big data, and forming a data stream for intelligence characterization.
Theft crime Intelligence characterization	The characterization of theft crime intelligence aims to perceive the risk scenario of theft crime and establish a matching mechanism between public security work and business needs, including two intelligence functions (scenario perception, intelligence characterization) and two intelligence tasks (scenario task matching, dynamic judgment and detection).	Intelligence Perception	By using clustering analysis, risk assessment, and other methods, we can extract intelligence information from various types of crime data and identify potential crime risk scenarios.
		Intelligence Characterization	Accurately identify and describe implicit intelligence, provide customized intelligence services for explicit intelligence needs, and ensure the adaptability and effectiveness of public security intelligence work.
Theft crime situational awareness	By utilizing the output intelligence flow characterized by intelligence, high dynamic and sustained perception of theft crime risks is achieved, including three intelligence functions (situational awareness, situational understanding, situational prediction) and two intelligence tasks (risk identification and monitoring, risk situational assessment).	Situational Awareness	Identify and extract various risk factors through criminal intelligence and risk data perception.
		Situational Understanding	Analyze the inherent correlation and evolutionary logic of theft criminal activities, apply understanding algorithms and relevant theories, and transform situational awareness risk signals into an interpretable crime pattern system.
		Situation Prediction	Forward looking deduction focusing on crime risks, using predictive algorithms for situation prediction, predicting and evaluating the degree of harm, evolution path, migration probability, and target priority of crime risks.
Theft crime Intelligence response	Providing support for optimizing police resource allocation and achieving scientific decision-making through crime situational awareness, including three intelligence functions (monitoring and early warning, decision response, post evaluation) and two intelligence tasks (risk intelligence push, risk prevention and control decision-making).	Monitoring And Early Warning	Real time monitoring and tracking of the development and evolution trends of crime risks, timely pushing warning information to communities and public security intelligence personnel, ensuring efficient and accurate intervention in theft crime risk management.
		Decision Response	Based on the evolution path of theft crime risk, triggering factors, and characteristics of criminals, scientific and effective prevention and control measures should be taken to reduce or eliminate crime risk, and prevent crime risk from transforming into actual criminal behavior.
		Post Event Evaluation	Through intelligence detection and response, further allocate police resources to prevent secondary and derivative criminal incidents, conduct criminal damage assessments, trace prevention and control processes, and evaluate the effectiveness of

intelligence assistance for responding to criminal risks or incidents.

3 PERCEPTION OF THEFT CRIME DATA

The comprehensive perception of theft crime data is an important fundamental work to ensure the accuracy and timeliness of public security intelligence work under complex conditions, and it is also an important method to eliminate the problem of incomplete criminal information in the intelligence decision-making process. For the perception of theft crime data, firstly, various intelligence data in the urban security environment are monitored, scanned, and extracted through horizon scanning method. Then, multi-source criminal intelligence data is annotated and processed through data parsing and data fusion to form a data stream for intelligence drawing process.

3.1 Criminal Data Acquisition

The perception of theft crime data emphasizes the real-time perception and acquisition ability of multi-source intelligence data, and focuses on the real-time monitoring and scanning of potential intelligence data in urban security environments. According to existing research, urban safety environment is usually divided into remote environment and task environment, covering political, legal, technological and other safety fields (such as technological changes, social structure changes, policy adjustments, etc.), with a large amount of data and complex forms. Therefore, the systematic acquisition and integration of multi-source data is an important foundational work for constructing a theoretical model of theft crime situational awareness. Horizon scanning, as a forward-looking monitoring method, continuously scans heterogeneous data sources such as open source intelligence data (social media, video surveillance, IoT devices, etc.) and national security related agency data (government work reports, judgment documents, etc.), achieving "systematic" acquisition of multi-source intelligence data in complex urban security environments and establishing an early identification framework for criminal risk signals. During the scanning process, specialized data probes can be deployed to capture real-time and dynamic data information in key areas such as social security, achieving refined crime data perception and improving the timeliness and completeness of criminal intelligence production.

3.2 Multi Source Data Fusion

The sources of theft crime intelligence data are extensive, massive, and complex in form. Only by fully integrating intelligence data from different dimensions and granularities can a standardized information flow be formed for the input intelligence characterization process. Data parsing is a prerequisite for data fusion, which involves data preprocessing to achieve data cleaning such as filling, denoising, and repairing of raw data. At the same time, it relies on data assimilation theory to achieve standardization and spatiotemporal granularity alignment of crime data. Data fusion is the further sorting of criminal intelligence data through aggregation management, using clustering, correlation, and classification algorithms to extract potential feature information contained in the data, integrating heterogeneous data modalities (structured case records, unstructured video streams, etc.), and constructing data streams for intelligence characterization. In practical work, because a large amount of intelligence data is distributed on the Internet platform and there is a "data barrier" with the public security intranet, the extraction and fusion of large-scale and real-time urban security data is limited. Therefore, building an efficient collaboration mechanism and fusion mode has become the key task of intelligence data sharing and fusion at this stage. In addition, we should actively promote the construction of a management system for theft of criminal data resources, securely store and manage criminal data, prevent the leakage of confidential information, and effectively safeguard data security.

4 CHARACTERIZATION OF THEFT CRIME INTELLIGENCE

The characterization of theft crime intelligence is the construction of a coupling mechanism between intelligence perception and decision-making needs, relying on intelligence theory and intelligence data for continuous understanding and feedback, systematically deconstructing intelligence information such as theft behavior subjects and environmental interaction patterns, and generating intelligence flows for situational awareness. For the characterization of theft crime intelligence, one is to explore the "implicit" information contained in intelligence data through intelligence perception, identify potential risk scenarios, and allocate existing intelligence resources reasonably; The second is to clarify the "explicit" intelligence needs through intelligence characterization, implement customized intelligence work, and improve the accuracy and efficiency of intelligence work.

4.1 Criminal Intelligence Perception

Due to the complexity and diversity of crime risk scenarios, a comprehensive perception of various risk factors is a prerequisite for ensuring the effectiveness of intelligence work. The perception of theft crime intelligence is a systematic methodology based on relevant theories of intelligence and criminology, which constructs a dynamic monitoring and analysis system for criminal activities. Its core is to perceive the "potential" risk information and "implicit" intelligence needs contained in intelligence data through analysis algorithms such as correlation analysis and

risk assessment. At the same time, deconstructing the environmental triggering mechanisms and subject object behavior patterns of theft crimes, utilizing intelligence perception and analysis methods to form expert knowledge and experience, and constructing a theft crime risk case database and knowledge base. To avoid knowledge redundancy and overload in the database, algorithms such as association and clustering are used to infer and classify the risk scenarios of newly added intelligence data, making the entire intelligence perception process more scientific and efficient.

4.2 Criminal Intelligence Characterization

In the context of "big security" and "big intelligence", the interaction between criminal subjects, environmental factors, and behavioral patterns presents multidimensional dynamic correlation characteristics, making the process of characterizing theft crime intelligence also require the implementation of systematic thinking. On the one hand, by actively monitoring crime triggering factors, deeply analyzing the "implicit" intelligence needs of law enforcement agencies, and establishing a scenario matching mechanism that is in line with business reality. At the same time, combined with the demand feedback closed-loop mode, a new round of crime data scanning and extraction will be carried out to promote iterative optimization of data collection dimensions. On the other hand, in response to the clearly defined "explicit" intelligence needs of law enforcement agencies, targeted perception and analysis of criminal intelligence data is carried out, strengthening the cognitive collaboration between intelligence analysts and law enforcement workers, and promoting the evolution of intelligence characterization process towards flatness and precision. Compared to traditional crime situational awareness systems that monitor the entire amount of data indiscriminately, this intelligence characterization architecture is designed with demand matching and feedback mechanisms, which can focus on the dynamic tracking and deep mining of high-value intelligence clues, achieve targeted optimization of intelligence resources, and avoid waste of resources such as "manpower", "material resources", and "computing power".

5 PERCEPTION OF THEFT CRIME SITUATION

Situational awareness is a way to enhance the ability to detect, understand, analyze, and respond to security threats from a global perspective, based on security big data. By collecting, integrating, and analyzing potential patterns and information contained in multi-source data in real time, it understands the current situation, predicts future trends, and assists in the decision-making process. In the field of public safety, situational awareness technology can help public security grasp urban safety dynamics, optimize security risk prevention and control, and police resource scheduling, further enhancing urban resilience. For the perception of theft crime situation, the classic theoretical framework Endsley model is used to construct, which includes three levels: theft crime situation perception, theft crime situation understanding, and theft crime situation prediction. At this point, the perception process of theft crime can be understood by obtaining, processing, and analyzing criminal intelligence data to explore the current behavior patterns, harmfulness, and risk evolution trends of theft crime.

5.1 Criminal Situation Awareness

Situational awareness is the initial level of theft crime situational awareness. Firstly, situational awareness algorithms are used to identify and extract various risk factors, construct a dynamic monitoring network for criminal activities, and accurately detect theft crime risks; Then, using learning rules and distributed reasoning methods, abnormal behavior patterns, environmental vulnerability mutations, and other risk and threat attributes are captured to achieve preliminary extraction or localization of criminal risk signals; Finally, by using a spatiotemporal prediction model to analyze crime data, the spatiotemporal correspondence between theft behavior and risk is analyzed, and a theft crime risk situation map is constructed. Situational awareness emphasizes the active detection ability of triggering factors for theft crimes, essentially achieving the "visualization" and "focus" of potential characteristics of criminal behavior through the perception of criminal intelligence and risk data.

5.2 Understanding the Criminal Situation

Situation understanding aims to analyze the inherent correlation and evolutionary logic of theft criminal activities, and use understanding algorithms to transform intelligence theory, criminology theory, and situational awareness risk signals into an interpretable crime pattern system. The process of situation understanding relies on the professional knowledge of expert teams, and through human-computer interaction, introduces a criminal intelligence understanding and analysis architecture based on artificial intelligence technology to promote intelligence tasks such as theft threat situation assessment, risk situation assessment, and risk evolution monitoring. In fact, this process focuses on multidimensional evaluation of crime triggering factors and causal chain reasoning, supporting the cognitive transition of law enforcement departments from phenomenon description to mechanism interpretation, and providing identifiable and interpretable theoretical anchors for the formulation of prevention and control strategies.

5.3 Crime Situation Prediction

Situation prediction focuses on forward-looking deduction of criminal risks, using prediction algorithms for situation assessment and prediction, tracking the evolution path of theft crime risks, assessing the degree of harm caused by theft crimes, and further perceiving potential derivative risks. At the same time, this process relies on the "swarm intelligence collaboration" technology to promote collaborative intelligence strategy analysis through interdisciplinary and cross platform collaboration, and implement efficient intelligence sharing mechanisms. In addition, constructing a "situation map" of theft crimes, quantitatively evaluating potential crime hotspots, spatiotemporal migration patterns, and the level of harm caused by criminal behavior, outputting predictions of crime transfer paths and prioritization of prevention and control targets, optimizing decision-making and resource allocation, thereby promoting the transformation of crime prevention and control from the "post disposal" paradigm to the "pre blocking" paradigm.

6 THEFT CRIME INTELLIGENCE RESPONSE

Criminal risk is a direct reflection of the potential occurrence of criminal events, and high-risk environments can significantly increase the probability of criminal events occurring. If prevention is not effective, it is highly likely to trigger criminal behavior. The response process of theft crime intelligence is based on the theory of intelligence led policing, combined with the theory of emergency life cycle and the general law of public safety risk evolution. The evolution of crime risk is divided into the pre risk evolution stage, the mid risk evolution stage, and the post risk evolution stage, corresponding to three intelligence functions: monitoring and early warning, decision-making response, and post evaluation. A closed-loop governance system of "early warning response evaluation" is formed to achieve full cycle control of crime risk.

6.1 Monitoring and Early Warning

Monitoring and early warning is the leading link in responding to theft crime intelligence, which comprehensively identifies potential crime risks through crime situational awareness in the pre evolution stage of crime risk. Relying on the strategy of "collective intelligence collaboration", we promote the integration of multi-source crime situation intelligence from networks, communities, public security, and other sources. Based on the actual needs of public security intelligence departments for risk situations, we push multi granularity warning intelligence such as community level risk indices and street level crime time distribution. In addition, by fully utilizing the "situation map" of crime risk, the development and evolution trend of theft crime can be tracked in real time, and the probability of risk transmission can be quantified based on the thermodynamic model of crime. High dynamic monitoring of key areas can be carried out to provide high confidence prior decision-making basis for public security departments.

6.2 Decision Response

Decision response focuses on the efficient transformation of early warning intelligence into prevention and control actions, that is, in the mid-term stage of crime risk evolution, crime situation intelligence is used to enable public security intelligence departments to fully understand the occurrence conditions, risk hotspots and evolution paths of theft crimes, as well as the inherent connections or similarities between different theft crime events, and to take scientific and effective measures to eliminate potential crime risk points and prevent the occurrence of criminal events. At the same time, based on actual crime risk situation intelligence and Pareto front analysis, a multi-level decision-making space of "patrol density response time prevention and control coverage" is constructed to determine the optimal police deployment plan. In addition, utilizing existing intelligence information and historical case information to construct an updated reasoning knowledge base and experience knowledge base, ensuring the sharing of intelligence resources among multiple departments and serving the governance of criminal security risks.

6.3 Post Evaluation

Post evaluation is the process of revealing the net effect of prevention and control measures and the reproduction of intelligence knowledge, that is, in the post event stage of risk evolution, continuous and highly dynamic intelligence perception is used to prevent the occurrence of secondary and derivative crimes, and the intervention efficiency, response speed, and accuracy of intelligence perception and response work are retrospectively evaluated. Assess the economic damage, facility damage, and negative social impact of theft incidents, and perceive changes in the community and public security perception index. In addition, establish a dynamic feedback mechanism of "prevention and control intensity crime evolution", inject the results of crime risk governance assessment into the risk analysis model and patrol strategy adjustment rule library, form a cognitive loop of "intervention evaluation optimization", continuously accumulate experience and strategies in theft crime governance, and promote the transformation of governance work mode from short-term prevention to long-term resilience construction.

7 CONCLUSION

A comprehensive understanding of the public safety situation, timely crackdown on illegal and criminal activities, and accurate elimination of criminal risks and hidden dangers are prerequisites for achieving modernization of social governance capabilities. By relying on crime situational awareness technology, a new concept, new ideas, and new

methods for the governance of theft crime intelligence have been formed. A theoretical model of crime situational awareness that integrates theft crime data perception, theft crime intelligence characterization, theft crime situational awareness, and theft crime intelligence response has been constructed, which can consolidate the theory of public safety intelligence, enhance community risk monitoring and early warning capabilities, promote the practical application of intelligence perception, and establish a comprehensive, three-dimensional and efficient social security protection system.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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INVESTIGATION ON THE AGGRESSION LEVEL OF PRIMARY SCHOOL STUDENTS

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Abstract: Objective This study aimed to investigate the aggression level of primary school students, explore the differences in aggression among different groups of students, and analyze the influencing factors. Method A total of 1,281 primary school students from 12 schools in 5 provinces were surveyed using the Buss-Perry Aggression Scale. Results The results showed that the overall detection rate of aggression among primary school students was 49.80%, and the total average score was 2.51, indicating a moderately high level of aggression. There were significant differences in aggression among students of different genders, grades, and family types. Conclusions These findings suggest that aggression is prevalent among primary school students and should be taken seriously in mental health education.
Keywords: Primary school students; Aggression; Demographic variables; Influencing factors

1 INTRODUCTION

In recent years, with the increasing prevalence of campus violence among younger children, aggression, a personality trait that emerges early in life and persists throughout, has received extensive attention from society[1]. For primary school students, who are in the initial stage of various psychological developments, aggression during childhood not only negatively impacts their current physical and mental health but also increases the risk of criminal behavior in adulthood[2].

In response to this issue, the Chinese department has issued several policies emphasizing the importance of assessing and preventing psychological problems in the early stages. For example, the "Opinions on Strengthening the Construction of the Safety Risk Prevention and Control System for Primary and Secondary Schools and Kindergartens" issued by the General Office of the State Council in 2017 clearly pointed out the need to predict and monitor adolescent delinquency. Such policies underscore the significance of early intervention in dealing with students' psychological problems.

Given this context, this study aims to address the following questions: What is the current level of aggression among primary school students? Are there differences in aggression levels among students of different genders, grades, birth orders, family types, and from different regions? What are the influencing factors? Answering these questions can help us better understand the aggression situation of primary school students and provide a basis for formulating targeted intervention measures.

2 SUBJECTS AND METHODS

2.1 Subjects

A total of 1,300 primary school students (aged 6 - 12 years) from 12 schools in Shandong, Hainan, Xinjiang, Shaanxi, and Hubei provinces were selected as the research subjects using the random cluster sampling method. After excluding invalid questionnaires, 1,281 valid questionnaires were obtained, with an effective rate of 98.54%. The distribution of demographic variables of the subjects is shown in Table 1.

Table 1 Distribution of demographic variables and descriptive statistical values of subjects (*N*=1281)

Variable category	option	Number（*n*）	Percentage （%）	*M*±*SD*
Gender	Male	695	54.3%	1.46±0.49
	Female	586	45.7%	
Grades	1	18	1.40%	3.50±1.14
	2	249	19.4%	
	3	373	29.1%	
	4	429	33.5%	
	5	134	10.5%	
	6	78	6.10%	
Family structure	Single	72	5.60%	2.86±0.48
	Regrouping	30	2.40%	
	Integrity	1179	92.0%	
Birth order	Eldest	471	36.8%	2.30±1.14
	Second	170	13.3%	

	Youngest	422	32.9%	
	Only child	218	17.0%	
Source of students	Rural	607	47.4%	1.59±0.41
	Urban	674	52.6%	

2.2 Methods

In this study, the Buss - Perry Aggression Scale revised by Liu Junsheng et al[3] was used to measure the aggression level of the research subjects. The revised scale consists of 20 questions, including 6 questions on physical aggression, 4 on hostility, 5 on anger, and 5 on substitute aggression. The scale uses a five - point scoring system, with "1" indicating that the content of the question is very different from one's own situation and "5" indicating that it is very similar. The theoretical median of the scale is 2.5 points, and the higher the total score, the more prominent the subject's aggression. In this study, the Cronbachαcoefficient of the full scale was 0.88, and the Cronbach α coefficients of the factors of anger, substitute aggression, physical aggression, and hostility were 0.74, 0.70, 0.70, and 0.69, respectively, indicating that the scale can be directly used to assess the aggression of primary school students.

2.3 Statistical Processing

2.3.1 Statistical Methods

SPSS26.0 software was used for data analysis. Mean and variance (*M*±*SD*) in descriptive tests were calculated to obtain the total aggression and scores of each dimension of primary school students. Independent - sample t - test was used to analyze the differences in aggression levels among students of different genders and from different regions. One - way ANOVA was used to analyze the differences in aggression levels among students with different demographic backgrounds such as grades, family types, and birth orders.

2.3.2 Implementation Procedures

The assessment was carried out in the classroom on a class - by - class basis. Before the test, the research purpose was explained in detail to the subjects, and an informed consent form was obtained from the subjects and their guardians. During the test, the filling order and precautions were explained according to the unified instructions. For lower - grade primary school students, the examiner explained the meaning of the questions by combining common examples in students' lives. To avoid interference and imitation among subjects, they were required to sit at a distance where they could not see others' questionnaires. The examiner recorded the subjects' behaviors and language during the preparation and creation process. After the test, the questionnaires were immediately collected on - site, and the examiner further verified the demographic information of the subjects based on the materials provided by the class teacher and subject teachers.

3 RESULTS

3.1 Overall Aggression Level and Descriptive Statistics of Each Dimension

The total aggression level and scores of each dimension of the 1,281 valid data in this study are shown in Table 2.

Table 2 Total Aggression Level and Scores of Each Dimension (*N=1,281*)

Variable	M	SD
Physical Aggression	2.53	1.03
Hostility	2.80	1.09
Anger	2.44	1.04
Substitute Aggression	2.32	0.90
Total Aggression	2.51	0.85

The average scores of physical aggression, hostility, anger, substitute aggression, and total aggression of the surveyed subjects were 2.53, 2.80, 2.44, 2.32, and 2.51, respectively. The average score of total aggression was 2.51, which was higher than the theoretical median of 2.5, indicating that the overall aggression of primary school students was at a moderately high level. Further analysis showed that 643 students had an average aggression score lower than 2.5, accounting for 50.20%, while 638 students had an average score exceeding 2.5, accounting for 49.80%, indicating the universality and extensiveness of aggression among primary school students. By comparing the scores of each dimension of aggression, it was found that the score of hostility (2.8 points) was the highest, much higher than the theoretical median of the hostility dimension of 2 points, indicating that primary school students mainly expressed aggression through implicit hostile attitudes. Followed by physical aggression (2.53 points), while the scores of

substitute aggression and anger were lower than the total average score of aggression, indicating that primary school students mainly expressed aggression through direct external physical aggression and implicit hostile attitudes.

3.2 Differences in Aggression among Students with Different Demographic Variables

3.2.1 Gender differences

The scores of 1,281 subjects in aggression and its various dimensions by gender are shown in Table 3. There were significant differences ($p < 0.001$) in the scores of physical aggression, hostility, anger, substitute aggression, and total aggression between male and female students. Specifically, male students had higher scores.

Table 3 Gender Differences in Aggression and Its Dimensions *(N=1,281)*

Variable	Male	Female	t	p
Physical Aggression	2.77±1.06	2.24±0.92	9.70	0.000
Hostility	2.95±1.08	2.61±1.07	5.71	0.000
Anger	2.58±1.02	2.27±1.04	5.48	0.001
Substitute Aggression	2.50±0.92	2.12±0.83	7.82	0.000
Total Aggression	2.69±0.84	2.29±0.81	8.77	0.000

3.2.2 Grade Differences

The scores of 1,281 subjects in each dimension of aggression and the total score by grade are shown in Table 4. There were significant differences ($p < 0.001$) in the total scores of aggression and the scores of each dimension among students of different grades. Post - hoc tests found that the total score of aggression of sixth - grade students was higher than that of other grades, indicating that aggression was more likely to occur in upper - grade primary school students.

Table 4 Grade Differences in Aggression and Its Dimensions *(N=1,281)*

Variable	1st grade	2nd grade	3rd grade	4th grade	5th grade	6th grade	F	p
Physical	3.05±0.88	2.37±0.89	2.60±1.13	2.38±1.02	2.45±0.98	3.04±0.91	8.27	0.000
Hostility	2.51±1.04	2.52±1.02	2.98±1.05	2.75±1.13	2.87±1.08	2.94±0.95	10.69	0.000
Anger	2.18±0.49	2.24±0.88	2.85±1.00	2.17±0.99	2.40±0.97	2.78±1.42	6.86	0.009
Substitute	2.15±0.41	2.13±0.73	2.16±0.81	2.13±0.90	2.79±0.68	2.81±0.73	9.64	0.000
Total Score	2.28±0.72	2.34±0.64	2.35±0.76	2.28±0.75	2.40±0.70	2.94±0.72	11.55	0.000

3.2.3 Birth order differences

The scores of 1,281 subjects in each dimension of aggression and the total score by birth order are shown in Table 5. There were no significant differences ($p > 0.05$) in the aggression of primary school students with different birth orders.

Table 5 Birth Order Differences in Aggression and Its Dimensions *(N=1,281)*

Variable	Eldest	Second - born	Youngest	Only Child	F	p
Physical Aggression	2.47±1.01	2.49±0.95	2.61±1.11	2.53±1.01	1.50	0.21
Hostility	2.73±1.09	2.79±1.02	2.86±1.11	2.83±1.11	1.11	0.35
Anger	2.40±1.07	2.38±0.92	2.53±1.04	2.39±1.04	1.57	0.20
Substitute Aggression	2.26±0.86	2.31±0.81	2.38±0.92	2.37±0.99	1.61	0.19

Variable	Eldest	Second - born	Youngest	Only Child	F	p
Total Aggression	2.45±0.83	2.48±0.76	2.58±0.87	2.51±0.89	1.85	0.14

3.2.4 Regional differences

The scores of 1,281 subjects in each dimension of aggression and the total score by regional source are shown in Table 6. There were no significant differences ($p > 0.05$) in the aggression of rural and urban school students. However, the total score of aggression of urban students was higher than that of rural students.

Table 6 Regional Differences in Aggression and Its Dimensions *(N=1,281)*

Variable	Urban	Rural	t	p
Physical Aggression	2.39±0.92	2.35±0.89	1.28	0.28
Hostility	2.73±1.03	2.71±1.01	0.46	0.71
Anger	2.32±1.01	2.16±0.96	1.01	0.39
Substitute Aggression	2.23±0.87	2.13±0.96	1.07	0.36
Total Aggression	2.99±0.76	2.81±0.76	1.22	0.30

3.2.5 Family type differences

The scores of 1,281 subjects in each dimension of aggression and the total score by family type are shown in Table 7. There were differences in aggression among different family structures ($p < 0.001$). Post - hoc test results showed that the total scores of aggression and the scores of each dimension of primary school students from divorced and re - combined families were significantly higher than those of students from intact families.

Table 7 Family Type Differences in Aggression and Its Dimensions *(N=1,281)*

Variable	Divorced	Re - combined	Intact		F
Physical Aggression	3.05±0.96	3.16±2.19	2.48±0.98	16.27	0.000
Hostility	3.30±0.95	3.01±1.14	2.76±1.09	8.88	0.000
Anger	3.20±0.93	2.74±1.05	2.38±1.03	22.84	0.000
Substitute Aggression	2.94±0.89	2.68±0.98	2.28±0.88	21.60	0.000
Total Aggression	3.11±0.79	2.91±1.13	2.46±0.83	23.87	0.000

4 DISCUSSION

4.1 Overall Aggression Level of Primary School Students

The results of this study show that the overall aggression level of primary school students is moderately high, which is consistent with the findings of Ma Hejing[4]. However, some studies have indicated that the number of primary school students with aggressive personality traits is very small[5]. These differences may be attributed to several factors. Firstly, different assessment tools were used. Many previous studies used methods such as parental and teacher ratings, which may be affected by social desirability and self - protection mechanisms. Parents tend to choose positive options to quantify their children's aggression, and teachers may have biased evaluations due to stereotypes. Secondly, factors such as the sample size, sample source region, and testing time of the research can also influence the results.

In terms of the specific dimensions of aggression, primary school students tend to express aggression through implicit hostile attitudes and external physical attacks. This is consistent with previous research. However, some scholars have pointed out that due to their young age and lack of strength, primary school students may mainly use verbal means to express aggression when in conflictl[6]. There are also differences in the manifestation of aggression among different grades. Lower - grade students may use more physical attacks, while higher - grade students may be more inclined to use hostile means. These differences may be related to the selected assessment tools and the grade distribution of the

research subjects. In this study, the selected sample covered all grades of primary school, and lower - grade students may show more implicit hostile attitudes due to self - protection or fear of authority.

4.2 Gender Differences in Aggression

The finding that male students are more aggressive than female students in this study is consistent with previous research on the aggression level of primary school students[7-9]. There are two possible reasons for this difference. Firstly, there are gender differences in innate physiological development. Although both boys and girls start physical and mental development in primary school, boys generally develop faster, which makes them more likely to use physical means to solve conflicts when facing setbacks. In contrast, girls are physically weaker and tend to hide their anger. Secondly, social culture defines gender roles. In many cultures, men are expected to be brave and powerful, while women are expected to be gentle and reserved. As a result, men may be more inclined to use violent means to solve problems to meet these expectations. However, some studies have found that there is no gender difference in aggression. For example, Zhang Ping[10]found that the aggression levels of male and female students aged 9 - 18 were similar. This may be related to the age range of the selected subjects. As students grow older, the difference in growth rates between male and female students decreases, and girls may even be more mature than boys in junior high school.

4.3 Grade Differences in Aggression

The significant differences in aggression scores among different grades in this study are consistent with the research of Liu Jia. The higher aggression scores of upper - grade students may be related to their self - concept development. As students grow older, their self - concept develops, and they may be more likely to initiate conflicts in interpersonal communication[11]. However, some studies have found that the aggression level of fifth - grade students is the highest[12-13]. This may be because the emotional regulation ability of fifth - grade students has not been fully developed, resulting in more frequent physical attacks. By the sixth grade, students' psychological maturity may enable them to better solve conflicts through effective strategies.

4.4 Birth Order Differences in Aggression

The finding that there is no significant difference in aggression among primary school students with different birth orders in this study is consistent with the discovery of Ma Hejing. In multi - child families, the eldest child may be more tolerant and accommodating as they have younger siblings to take care of. According to the resource allocation theory, the second - born and youngest children may face limited resources, which can lead to jealousy and competition, and they may express their dissatisfaction through aggression. Regarding the difference between only - children and non - only - children, some studies have found that non - only - children have higher aggression scores[14-15], while others believe that only - children are more likely to show aggressive behavior. The inconsistent conclusions may be due to differences in the survey samples and the way of classifying birth order. In this study, non - only - children were further refined, which may have affected the results.

4.5 Regional Differences in Aggression

The result that there is no significant difference in aggression between rural and urban primary school students in this study is consistent with the research of Liu Lu. However, some researchers believe that urban students have higher aggression levels[16]. This may be because urban parents are often busy with work and have less time to accompany their children. In addition, the developed media in big cities may expose children to more violent content, which can be a source of imitation. On the other hand, some studies have found that rural students have higher aggression levels. This may be related to the low educational level of rural parents and the lack of positive role models and effective conflict - solving strategies. The difference between this study's conclusion and others may be due to the fact that the rural schools selected in this study are mostly located in the urban - rural fringe, which is different from traditional rural schools.

4.6 Family Type Differences in Aggression

The finding that primary school students from divorced and re - combined families have higher aggression levels than those from intact families is consistent with the research of Liu Lu. The lack of parental involvement in single - parent families may lead to parenting distress and dysfunctional parent - child interaction, which can increase children's aggression[17]. Some scholars also believe that the lack of material resources in single - parent families may cause children to feel deprived and lead to aggressive behavior [18]. However, Zhao Zhu found no significant difference in verbal and physical aggression between primary school students from intact and divorced families. This may be due to differences in the research tools used and the sample selection[19]. In this study, the proportion of intact families in the sample was relatively large, which may have affected the results. This reminds us to increase the sample size and balance the sample source in future research to improve the generaliz ability and ecological validity of the research results[20].

5 CONCLUSION

This study investigated the aggression level of 1,281 primary school students using the aggression scale and found the following results:

(1) The overall detection rate of aggression among primary school students was 49.80%, and the total average score was 2.51, which was higher than the theoretical median of 2.50. Implicit hostile attitudes and external physical attacks were the main manifestations of aggression.

(2) Due to innate physiological development characteristics and social cultural expectations for gender roles, there were significant differences *($p < 0.001$)* in the total scores of aggression and the scores of each dimension among primary school students of different genders. Specifically, male students had higher aggression levels than female students.

(3) Due to the imbalance and mismatch in physical and mental development, there were significant differences *($p < 0.001$)* in the total scores of aggression and the scores of each dimension among primary school students of different grades. The first - grade students had higher physical aggression scores, the third - grade students had more prominent anger and hostility, and the sixth - grade students had a higher total aggression score. In other words, primary school students at the young - to - primary and primary - to - junior high school transition stages had stronger aggression.

(4) There were no significant differences *($p > 0.05$)* in the total scores of aggression and the scores of each dimension among primary school students with different birth orders, and there was no difference in aggression between only - children and non - only - children.

(5) There were no significant differences *($p > 0.05$)* in the total scores of aggression and the scores of each dimension among primary school students from different regions, indicating that there was no significant difference in the aggression levels of rural and urban primary school students.

(6) There were significant differences *($p < 0.001$)* in the aggression levels of primary school students from different family types. Specifically, the aggression of primary school students from divorced and re - combined families was generally higher than that of students from intact families.

In conclusion, aggression, as a negative and implicit personality trait, is particularly obvious in the primary school student group. Due to differences in innate physiological development, social culture, role expectations, and living environment, there are significant differences in aggression among different demographic variables. Therefore, in future clinical psychological counseling and front - line mental health education, it is necessary to use multiple assessment tools to accurately identify primary school students with aggressive tendencies in advance, strengthen the prevention and attention to primary school students' aggression, and formulate targeted educational plans and intervention measures for timely guidance and education.

COMPETING INTERESTS

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REFORM OF TRAINING MODE FOR LOGISTICS MANAGEMENT PROFESSIONALS IN APPLIED COLLEGES AND UNIVERSITIES UNDER THE BACKGROUND OF DIGITAL ECONOMY

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Abstract: The digital transformation in the logistics industry has imposed new demands on cultivating logistics management majors in application-oriented universities. Revolutionizing the training model of logistics management majors to match the new requirements has become an issue that demands immediate solutions for application-oriented universities. For this purpose, we sort out the changes in demands for talents in the logistics industry empowered by the digital economy, analyze and summarize the existing problems in the cultivation of logistics management majors in current application-oriented universities, and put forward reform suggestions for the cultivation path, intending to provide a reference basis for the innovation of cultivation in the logistics management major of application-oriented universities.

Keywords: Digital economy; Logistics management major; Talent cultivation; Teaching reform

INTRODUCTION

In 2023, the scale of China's digital economy expanded to 53.9 trillion yuan, representing a year-on-year increase of 3.7 trillion yuan. This growth elevated its share of GDP to 42.8%, solidifying the digital economy as a critical pillar of the national economy. The advancement of internet technology and its pervasive application across society have positioned the digital economy not only as a vital engine for identifying new global economic growth points but also as an enduring force driving improvements in economic quality and deep structural optimization within industries[1].Logistics serves as the foundational infrastructure of the digital economy,The realization and advancement of the digital economy rely on an efficient and comprehensive logistics system. The overall capacity of this logistics system directly influences the depth and extent of digital economic development[2].The development of the digital economy has facilitated the rapid transformation and upgrading of the logistics industry[3].In terms of infrastructure, logistics enterprises have introduced intelligent warehousing systems, automated sorting centers, and smart transportation networks to enhance operational efficiency and accuracy. Additionally, the adoption of drones and autonomous vehicles for last-mile delivery has significantly reduced labor costs while improving delivery speed and safety. In terms of operational coordination, empowered by the digital economy, network freight platforms have seen substantial advancements. These platforms not only integrate fragmented logistics resources to improve resource utilization and reduce transportation costs but also optimize transportation routes and vehicle usage, thereby reducing energy consumption and carbon emissions, promoting green logistics. Consequently, logistics enterprises are increasingly moving towards informatization, intelligence, and automation. The rapid development and digital transformation of the logistics sector have also created new demands for logistics management professionals that differ from those in the traditional logistics industry[4].The proficiency in information technology, data analysis capabilities, and the extent of practical experience have become key considerations in the recruitment of logistics management professionals by logistics enterprises[5].In the context of the high standards and stringent requirements imposed by the digital economy, the development and construction of undergraduate programs in logistics management at universities have become especially critical[6].The proficiency in information technology, data analysis capabilities, and the extent of practical experience have become key considerations in the recruitment of logistics management professionals by logistics enterprises[7].How to innovate the training model for logistics management majors in application-oriented universities to align with the current talent demands of the logistics industry has become an urgent issue that requires immediate attention. To address this, this paper will analyze the talent demand situation in the logistics sector under the influence of the digital economy, examine the challenges faced in the current training of logistics management professionals, and propose reform suggestions for the training pathways for reference[8].

1 ANALYSIS OF THE DEMAND FOR LOGISTICS MANAGEMENT TALENTS IN THE CONTEXT OF DIGITAL ECONOMY

Under the background of the digital economy, the logistics industry has undergone significant changes, gradually evolving towards intelligence, efficiency, and informatization. This has led to a transformation in the demand for logistics management talents, mainly manifested in an increased demand for compound talents, a decreased demand for

basic operation position talents, and an increased demand for talents with practical experience.

1.1 Increased Demand for Interdisciplinary Talents

According to statistics, the number of patent applications related to smart logistics in China in 2021 was 291, an increase of 84 compared to 2020. With the development of smart logistics, the demand for interdisciplinary talents in the logistics industry has also increased. Besides logistics management knowledge, logistics professionals are required to have information technology capabilities, data analysis skills, and cross-disciplinary knowledge. Specifically, it is manifested as follows: (1) Information technology capabilities: Firstly, modern logistics emphasizes operational efficiency and accuracy, which requires the use of modern information technology for real-time monitoring and optimization of the logistics process. For example, GIS and GPS. Secondly, contemporary smart logistics requires logistics professionals to master Internet of Things, cloud technology, etc., to promote the intelligence and automation of the logistics process and achieve the goal of reducing error rates. (2) Data analysis: Modern logistics often uses data analysis to optimize the allocation of logistics resources, identify waste in the logistics process to save costs. At the same time, the industry also uses logistics data analysis to predict future changes in logistics demand and market conditions based on historical data. (3) Cross-disciplinary knowledge: Contemporary logistics involves many disciplines such as management, economics, transportation, and computer science. Only by comprehensively applying these knowledge can contemporary logistics problems be solved.

1.2 Reduced Demand for Basic Operational Positions

With the development of the digital economy, the logistics industry is undergoing a digital and intelligent transformation, leading to a significant decrease in the demand for basic operational positions. Positions characterized by high repetition and low technical content are increasingly being replaced by automated equipment and intelligent systems. For instance, the advancement of intelligent warehousing has seen the widespread adoption of automated high-rise warehouse technology. By 2023, China's inventory of automated high-rise warehouses surpassed 10,000 units, significantly reducing the need for basic operational roles in logistics warehouses. Additionally, SF Express' fully automated transfer hubs, equipped with advanced sorting equipment, can handle the entire process from unloading at the station to sorting and loading, achieving nearly unmanned and fully automated sorting operations. This innovation has eliminated a substantial number of basic operational positions in the express delivery sector. It is evident that the reduced demand for basic operational positions is a clear trend in the logistics industry, driven by the empowerment of the digital economy.

1.3 Increased Demand for Talents with Practical Experience

For application-oriented universities, graduates from logistics management programs predominantly enter various functional positions in the logistics industry, such as transportation management, warehousing management, customs declaration, distribution, and customer relationship management. Under the empowerment of the digital economy, these positions not only require a solid grasp of basic logistics theoretical knowledge but also demand practical experience. In the recruitment process for these positions, logistics enterprises place greater emphasis on applicants' practical abilities, professional skills, and occupational qualities. Influenced by the broader economic environment, companies have significantly reduced their willingness to invest time and resources in training new employees. Instead, they prefer to hire individuals who already possess practical experience and can quickly adapt to the work environment and meet job requirements.

2 PROBLEMS IN THE CULTIVATION OF LOGISTICS MANAGEMENT TALENTS IN APPLIED COLLEGES AND UNIVERSITIES

2.1 The positioning of talent cultivation is disconnected from the demands of the industry.

With the widespread application of technologies such as big data, artificial intelligence, the Internet of Things (IoT), and cloud computing in the logistics industry, the structure of the logistics sector has undergone significant transformation. Business processes driven by these advanced technologies have been reengineered, leading to updates in job content, knowledge requirements, and technical standards. Consequently, logistics management professionals are now required not only to possess traditional logistics knowledge but also to master advanced technical skills. To ensure that graduates from application-oriented universities can rapidly adapt to market demands, it is imperative to redefine the representative job contents of the logistics industry, establish updated standards for professional competencies, and revise talent cultivation plans accordingly. However, many application-oriented universities still adhere to outdated curriculum frameworks and fail to make timely adjustments. While some institutions have introduced courses related to the digital economy, such as "Big Data Technology" and "Python and Big Data Analysis," these additions often lack full integration with the core logistics management curriculum. As a result, the students they produce struggle to meet the market's demand for high-quality, interdisciplinary logistics professionals.

2.2 Classroom teaching content and mode have not adapted to the development trend of the industry

With the digital economy empowering the logistics industry, the industry is undergoing rapid changes. The problem of lagging classroom teaching content and mode innovation in many applied universities has gradually emerged. The main manifestations are as follows: (1) The teaching content is overly theoretical, and the teaching cases are outdated. Currently, the logistics management major courses still focus on theoretical instruction, with few combinations of theoretical knowledge and practical cases. This results in students having theoretical knowledge but being unable to apply it in practice. The teaching cases mentioned in the course textbooks and teaching process are mostly outdated. For new models such as "smart logistics" and "unmanned warehouses", they are only briefly mentioned without in-depth explanation. This leads to students' knowledge lagging behind the industry development, increasing the barriers for students to enter the enterprise after graduation. (2) The teaching methods are monotonous, and the assessment mode has not kept up with the times. The teaching form of most courses still remains at the stage where teachers unilaterally teach through blackboard writing or PPTs. Under this mode, students' learning interest is low, and the teaching effect for practical content that requires hands-on mastery is also poor. Modern logistics places more emphasis on students' practical ability and independent problem-solving ability, making the innovation of teaching methods particularly important. At the same time, the traditional assessment method of combining regular performance with final exams is difficult to fully evaluate practical teaching content and students' ability to solve real problems. Therefore, innovating the assessment mode and breaking through the framework of fixed and single assessment methods is also an important issue that needs to be addressed in the education and teaching of the logistics management major in the context of the digital economy.

2.3 Lack of Innovation in Practical Teaching

Students majoring in logistics management in application-oriented universities mostly seek employment in logistics-related enterprises. Therefore, their practical abilities and the capacity to quickly adapt to job positions are particularly important. However, the current practical teaching models in most universities are insufficient in terms of both breadth and depth, making it difficult for students to meet the talent demands of enterprises. As a result, enterprises have to spend time, money and human resources to make up for the deficiencies of students. The problems existing in practical teaching mainly include: (1) The practical teaching model is monotonous. Currently, most universities complete off-campus practical teaching by arranging students to visit enterprises, participate in non-technical work in enterprises, and complete graduation internships. This makes it difficult for students to deeply understand and master practical operations, and also makes it difficult for them to discover and overcome problems arising in practical operations. This is not conducive to the cultivation of students' problem-solving abilities, nor does it help them have a deep understanding of the difficulties they may encounter in their future jobs. (2) Teachers have insufficient grasp of the industry's cutting-edge developments. Currently, universities have introduced a large number of high-level talents to undertake front-line teaching work. Most of them are doctoral students who have never worked in the front-line positions of logistics enterprises and thus have no understanding of the practical skills required by the positions. This limits the possibility of teachers' innovation in practical teaching. (3) Limited practical teaching resources. Some universities have insufficient investment in the update and expansion of practical teaching resources, resulting in outdated experimental equipment, limited training venues, and insufficient and uneven quality of off-campus training bases. These resource limitations severely restrict the innovation and development of practical teaching.

2.4 Inadequate Depth of School-Enterprise Cooperation

The logistics industry has undergone rapid transformation driven by the digital economy. School-enterprise cooperation is the optimal pathway for universities to promptly capture the latest developments in the industry. However, at present, most school-enterprise collaborations in universities remain superficial and lack substantive deep integration. Firstly, many colleges and universities' school-enterprise cooperation is limited to graduation internships and employment, while cooperation in core areas such as curriculum design, teaching methods, and research projects is relatively weak. This shallow cooperation model makes it difficult for schools to accurately grasp the latest developments in the logistics industry and integrate the latest industry knowledge and technologies into teaching in a timely manner, thereby affecting the quality of student cultivation. Secondly, the goals of school-enterprise cooperation are not clear. Colleges and universities do not have specific goals for school-enterprise cooperation, resulting in unquantifiable cooperation outcomes and hindering the iterative update of the school-enterprise cooperation model. Enterprises do not recognize the impact and significance of school-enterprise cooperation on their own development and cannot see the benefits of school-enterprise cooperation for themselves, thus lacking enthusiasm for it. Thirdly, there is a lack of effective communication platforms and exchange mechanisms between colleges and universities and enterprises. Schools have insufficient understanding of the actual needs and development trends of the logistics industry, while enterprises also lack a full understanding of the educational resources and teaching capabilities of schools. This information asymmetry makes it difficult for both sides to form effective complementarity and synergy in the cooperation process, thereby affecting the effectiveness of the cooperation.

3 REFORM SUGGESTIONS FOR THE TALENT CULTIVATION PATH OF LOGISTICS MANAGEMENT MAJOR IN APPLIED UNIVERSITIES

3.1 Deeply Revise the Talent Cultivation Plan

Conduct comprehensive research on enterprise demands and systematically analyze the specific changes in job positions and the structural shifts in talent requirements within the logistics industry during its transformation and upgrading. This process should meticulously examine the impact of industry changes on enterprise operational models, business processes, and organizational structures, thereby exploring the redefinition of job functions and responsibilities, as well as the evolving requirements for knowledge, skills, and competencies. Based on this analysis, thoroughly revise and enhance the existing talent cultivation plan to ensure it remains up-to-date and accurately reflects industry needs. Additionally, anticipate industry trends with a forward-looking perspective, staying ahead of actual enterprise development needs. The goal is to cultivate versatile talents proficient in logistics management while possessing cross-disciplinary knowledge and skills, enabling them to meet the challenges and seize the opportunities presented by the future logistics industry.

3.2 Optimize the Allocation of Teaching Staff

To enhance the quality of education in logistics management and cultivate high-quality talents that meet the demands of the digital economy era, it is necessary to comprehensively train the existing teaching staff. Specific measures include: (1) Strengthening professional skills training for teachers. For the teaching team, professional skills training should be intensified, not only focusing on the update of theoretical knowledge but also emphasizing the improvement of practical skills. Through regular organization of professional skills training, teaching workshops, and other activities, ensure that teachers can master and effectively impart professional knowledge, thereby enhancing teaching levels and quality. (2) Building a teacher development platform and deepening school-enterprise cooperation. Establish long-term and stable cooperative relationships with enterprises to provide teachers with diversified development platforms such as on-the-job training, enterprise lectures, and on-site visits. Through in-depth enterprise practice, teachers can keep up with the latest industry trends, understand the latest market demands and technological developments, thereby enriching and optimizing teaching content and enhancing the practicality and pertinence of teaching. (3) Enriching the composition of the teaching staff to achieve integration of industry and education. Actively recruit managers or engineers with rich logistics experience from enterprises to join the teaching team as part-time teachers or visiting professors. They will bring the latest industry information and practical experience to students, jointly design courses and guide practices with in-school teachers, achieving integration of industry and education and enhancing the effectiveness and innovation of teaching. (4) Implementing a dual-mentor system to promote the integration of learning and work. For senior students, assign both school and enterprise mentors to combine theoretical learning at school with practical work in enterprises, achieving an organic integration of learning and work. Through the joint guidance of dual mentors, students can better adapt to the social environment, smoothly transition to their careers, and enhance their employment competitiveness and career development potential.

3.3 Diversified School-Enterprise Cooperation Models

To deepen school-enterprise cooperation and enhance educational quality and students' practical abilities, the following measures can be taken: (1) Introduce an enterprise mentor teaching mechanism. Incorporate practical teaching elements into theoretical courses and invite enterprise mentors with rich industry experience to share industry trends, cases, and experiences through lectures and elective courses, thereby enhancing students' industry understanding, increasing their learning interest and practical abilities, and enabling them to better integrate theoretical knowledge with practice. (2) Implement diversified internship and training programs. Schools should actively collaborate with logistics enterprises to organize multi-level internship and training programs for students, ranging from enterprise visits to on-the-job internships, allowing them to deepen their understanding of the industry and accumulate practical experience through learning in the actual working environment of enterprises, and adapt to the workplace in advance. (3) Carry out joint school-enterprise project cooperation. Schools and logistics enterprises should cooperate on projects, such as jointly researching topics, solving practical problems, and developing innovative products or services, providing students with opportunities to collaborate with enterprises and promoting the development of their practical abilities and innovative thinking. (4) Host special lectures and exchange meetings. Invite front-line practitioners and senior executives from logistics enterprises to give lectures and hold exchange meetings for students, broadening their horizons and helping them better understand the latest developments in the industry. (5) Regularly hold cooperation exchange meetings and teacher training sessions. Schools should regularly organize cooperation exchange meetings, inviting representatives from partner enterprises to have face-to-face exchanges with teachers. By actively participating in relevant training activities of partner enterprises, teachers can enhance their practical abilities and industry understanding, better grasping the current demands of logistics enterprises. At the same time, such exchange meetings can also provide a platform for teachers to jointly discuss new ways of student cultivation in the era of smart logistics with enterprises. Through such a cooperation and exchange mechanism, schools can continuously optimize their teaching plans and methods to better meet the needs of industry development. (6) Development of virtual practice platforms. Schools can collaborate with

enterprises to build virtual practice platforms, breaking the time and space limitations of traditional teaching and providing students with more flexible and diverse learning experiences. This will offer students more convenient and efficient learning methods, improving their learning outcomes and practical abilities.

3.4 Innovative Practice Teaching Model

In the context of the rapid development of the digital economy, the practice teaching model for logistics majors urgently requires innovation to more effectively cultivate students' practical skills and innovative thinking. Specific measures include: (1) Integrating theory and practice to promote coordinated development. Practice teaching should not be regarded as a supplement to theoretical teaching, but should develop in coordination with it to form an organic whole. In the practice teaching of the logistics major, theoretical teaching content should be effectively applied to practice, enabling students to deepen their understanding of theory through practical operations and use theory to guide practice. For example, theoretical knowledge can be combined with practical operations through methods such as simulating logistics processes and case analysis to help students better master logistics knowledge and skills and improve their ability to solve practical problems. (2) Enriching the forms of practice teaching to enhance teaching attractiveness. For instance, organizing debate competitions to allow students to discuss hot issues in the logistics field; holding reading clubs to guide students to read classic works in the logistics major; conducting film-watching activities to have students watch documentaries or films related to logistics; and conducting social surveys to enable students to understand the current situation and development trends of the logistics industry. These diversified forms of practice teaching not only increase the interest of teaching but also allow students to learn and grow in a relaxed and pleasant atmosphere. (3) Establishing Practice Teaching Bases to Ensure the Smooth Progress of Teaching Activities. Practice teaching requires adequate resources and stable bases as support. To this end, colleges and universities should actively integrate practice teaching resources, leveraging both on-campus and local resources to establish relatively stable practice teaching bases. For instance, by forming cooperative relationships with local logistics companies, warehousing centers, ports, and other relevant entities, these bases can provide students with more practical opportunities and platforms, enabling them to learn and grow in real-world working environments. Simultaneously, the establishment of such practice teaching bases ensures a robust foundation for the smooth conduct of teaching activities.(4) Building an integrated practice teaching chain of industry-university-research-innovation. Practice teaching should not be limited to the campus but should also closely cooperate with external entities such as enterprises and research institutions. Colleges and universities should build an integrated practice teaching chain of industry-university-research-innovation, allowing students to come into contact with the latest scientific research achievements and industry trends in practice. For example, collaborating with logistics enterprises to carry out scientific research projects and having students participate to understand the latest technologies and applications in the logistics field; cooperating with research institutions to jointly conduct research and innovation in the logistics field. This cooperative model can not only enhance students' innovative thinking and practical application abilities but also provide more opportunities and platforms for their future employment and entrepreneurship.

4 CONCLUSION

Under the empowerment of the digital economy, the logistics industry is progressively advancing towards informatization, intelligence, and automation. Consequently, the demand for talents is shifting towards a more compound, innovative, and practice-oriented profile. This transformation poses significant challenges to the talent cultivation model in application-oriented universities' logistics management programs. Reforming the logistics management training model to align with contemporary industry demands has become an urgent priority for these institutions.

This paper comprehensively examines the entire process of talent cultivation in logistics management and proposes several strategic pathways for reform. These include: (1) deeply revising the talent training program to adapt to structural changes in talent demand; (2) optimizing the allocation of teaching staff to achieve seamless integration of industry and education; (3) diversifying school-enterprise cooperation models to enhance educational quality and students' practical abilities; and (4) innovating practical teaching models to cultivate students' practical skills and innovative thinking. It is anticipated that these recommendations will provide valuable insights and serve as a reference for the reform of logistics management talent cultivation in application-oriented universities within the context of the digital economy.

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NEGATIVE COGNITION OF TERRORIST ATTACKS AND FDI INFLOWS: ANALYSIS BASED ON THE "3.1" ATTACK IN KUNMING

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Abstract: Background: In today's world of increasing globalisation, foreign direct investment (FDI) plays a crucial role in driving a city's economic development. However, when a city suffers a serious security incident, such as a terrorist attack, the economic impact can be far-reaching. Take the violent terrorist incident in Kunming in 2014 as an example, this incident not only brought great panic and harm to the local people, but also had a non-negligible impact on Kunming's economy.The statistical data shows that the violent terrorist event in Kunming in 2014 led to a dramatic decline in foreign direct investment (FDI) in the city, the mental health and psychological characteristics of foreign investors, such as perceived norms of economic development, may be affected.
Subjects and Methods: In order to explore the causal relationship between FDI decline and the attack, this study collects and collates relevant economic data from more than one hundred prefecture-level cities in central and western China. By analysing the data, we expect to understand the specific impact of terrorist attacks on FDI and the mechanisms of their impacts.This study uses the Synthetic Control Method (SCM) to study whether the 2014 attack caused the decline in FDI in the following two to three years to assess its impact on investors' mental health and psychological profiles.
Results: The results show that the control group of other prefecture-level cities has a good fitting effect on Kunming City through the SCM; the changing trend in FDI in the synthetic control group before 2014 is basically the same as that in the real Kunming City. The three years following 2014 see a huge deviation between the real Kunming FDI curve and the synthetic control group, with the negative impact being most evident in 2016. FDI in Kunming was more prominently affected by the terrorist attacks, demonstrating a prolonged period of fear-related negative emotions and impaired economic cognitive norms, resulting in uncertainty about the psychological needs of investors, increased anxiety, reduced credibility towards the city, and weakened social trust.
Conclusions: This indicates that the attack in 2014 did cause the decline of FDI in Kunming City, and the negative impact had a time lag of about one year. This study further explores the mechanisms by which terrorist attacks lead to a decline in FDI, with the aim of providing ideas for quantifying the economic impact of terrorist attacks, and thus reducing the negative impacts in terms of investors' mental health and psychological profiles.
Keywords: Negative Cognition;Terrorist attack; FDI inflows; Synthetic Control Method (SCM); Mental health

1 INTRODUCTION

Since the terrorist event in 2011, terrorist attacks have increasingly become an area of interest and concern for academic researchers. To date research has extended from the fields of international politics and national security to international economics, including the perspective of international investment and international trade[1]. In academic research, the economics of terrorism, an interdisciplinary topic of economy and security, is relatively mature.
The danger of terrorism faced by China is closely related to the changes in the macro international environment and the security situation in surrounding countries. The withdrawal of some countries from war-prone regions has left a series of disasters in its wake, leading to an increased threat of 'spillover violence' from terrorist forces. Frequent periods of unrest in the Middle East and North Africa, have seen an accelerated growth in international terrorist activities, with some countries becoming the latest training ground for violent and terrorist organizations from various countries. Terrorist organizations were particularly active in 2014, with a number of incidents occurring around the world[2].
Although China has not experienced a flood of terrorist attacks, its vast territorial size and numerous ethnic groups, accompanied by the complex national conditions of neighboring countries, have meant that China is naturally concerned by terrorism. China experienced some terrorist attacks between 2013 and 2014 [2].
Amongst those attacks mentioned above, the most brutal incident, which had the worst impact and resulted in the most serious casualties, was the "3.01" attack in Kunming in 2014. According to the "China National Security Research Report in 2014", the attack took place in the ticket office at the railway station and at other places in Kunming city. Armed with machetes, the attackers inflicted violent attacks on innocent civilians, resulting in 29 deaths and 143 injuries in total.
This event has attracted wide attention from the media and scholars in various academic fields in China. However, most existing literature on this attack is from the perspective of national security, crime fighting, and media communication, etc. There is a lack of research on the economic impact of the attack. And there is a lack of research on the mental health and psychological profile of foreign investors.
Terrorist attacks are commonly thought to trigger panic in a region, distorting the allocation of resources and leading to

capital flight. Hu and Lai [3] referred to the harmful impact of terrorist attacks at varying levels: cultural, social, economic, political, and many others. They calculated that terrorism would heavily block economic development by causing a high level of property damage and a large number of casualties. Through an empirical study of 187 countries, Fernanda found that terrorist attacks negatively impact private consumption growth rate and private investment growth rates. For every additional attack, the private consumption growth rate will drop by 0.98% and the private investment growth rate by 0.27%. Dinesen and Jager [4] studied the effect of terrorist attacks on confidence in political institutions in some countries. They identified that terrorism would increase trust in government institutions. However, specifically regarding the "3.01" attack in Kunming, the question is whether the attack has led to a decline in FDI in the region. In other words, is there a causal relationship between the "3.01" attack and the change in FDI? And what is the effect mechanism? These questions are the research focus of this study.

The contributions and innovations of this paper lie in the following. Firstly, most existing literature focuses on terrorist attacks on the West, whilst the terrorist threats in Asia are rarely mentioned, particularly those in China. There has been little research on the impact of terrorist attacks in China. Given the huge political, cultural and economic differences between regions, the results in other countries may not be completely consistent with those in China. This study focuses on terrorist attacks in China, taking the attacks in Kunming in 2014 as a basis for examining the impact of the attack on FDI in Kunming. The first reason for choosing this as the research object is that the number and scale of domestic terrorist attacks in China is relatively small, and the economic impact is not obvious, and subsequently little attention has been given to this field by existing academic researchers. Additionally, solely focusing on a city or region where violent terrorist attacks once occurred, may lead to the conclusion that such attacks still have a relatively distinct impact on the indicators of a certain region.

Secondly, existing research has investigated the "3.1" attack in Kunming from the perspectives of national security, the fight against crime, media communication, etc. There is a lack of research on the economic impact of the attack. The data shows that FDI decreased after the terrorist attack in Kunming in 2014. However, there is a lack of empirical studies testing the causal relationship between the "3.01" attack and the change in FDI in this region. This study uses the Synthetic Control Method (SCM) to study the causal relationship between the Kunming attack and the decline of FDI in the city, thus enriching the research on the impact of terrorist attacks in China.

Thirdly, this study further discusses the specific mechanism of the decline of FDI in Kunming caused by terrorist attacks at both the macro and micro levels. And it explores the psychological characteristics such as anxiety, negative emotions, and economic cognitive norms resulting from the decline in FDI. This study is also of great theoretical and practical significance in the formulation of Chinese regional economic and security strategy, and in the effective and stable development of regional investment activities.

The remainder of the paper is organized as follows: Section 2 is the literature review; Section 3 conducts a counterfactual causal analysis and produces the synthetic control model; Section 4 analyzes the results of the synthetic control and further uses the placebo test to test the significance and robustness of the empirical results; Section 5 is the mechanism test at the macro and micro levels. The final section provides conclusions and policy implications.

2 LITERATURE REVIEW

2.1 The Economic Effect of Terrorist Attacks

Since the famous terrorist attack in 2001, there has been an increasing number of studies on the economic effect of terrorism in Western countries, including both theoretical and empirical research[5].

Some scholars have found that terrorism largely impacts economic development. Abadie [6] studied the economic impact of terrorist activities ina certain country, and found that following the terrorist attacks of the 1970s, the country lost about 10% of its per capita GDP when compared with the control group. This is the earliest application of the SCM and one of the earliest studies to quantify the economic impact of terrorist attacks. Khan and Yusof [7]found that terrorist attacks had generated economic recession in a certain country. They found that the degree of impact of terrorism on economic performance gradually increased from 2002 to 2014, rising from -0.02% in 2002 to -2.95% in 2014. This means that the negative economic impact of terrorism reduced economic growth by 2.95% compared with the absence of terrorism.

Additionally, a large volume of literature focuses on the trade effect of terrorist attacks. One such category mainly focuses on the West, including America, Europe, North Africa, and the Middle East. Blomberg and Hess [8] investigated the impact of terrorist attacks on trade in terms of tariff imposition. The study found that the marginal effect of terrorist attacks on trade "taxation" even exceeded the impact of language barriers and WTO membership on trade. Gaibulloev and Sandler [9] focused on the impact of anti-terrorism measures on trade cooperation. They found that counter-terrorism measures had strengthened border security and transport hubs, and further reduced the efficiency of trade cooperation by extending customs clearance times and increasing insurance and security costs. The study was an extension of research on the economic effects of terrorist events, focusing on the indirect economic effects of terrorist attacks.

However, little research exists on the effect of terrorist threats in Central Asia, South Asia, and Southeast Asia – the area surrounding China. In recent years, some Chinese scholars have focused mainly on the trade effect on neighboring countries, including the "One Belt One Road" routes and the "Pakistan Economic Corridor", looking at the impact of terrorist threats on China's trade in these countries. Chen et al. [10]studied the impact of terrorist attacks on the trade

efficiency of the "One Belt One Road" countries and China from the perspective of the heterogeneity of targets. According to their study, attacks against "personal and property" targets have an apparent impact on trade efficiency in the "One Belt One Road" countries, but attacks on "commercial" targets have an even greater impact on China's trade efficiency.

The study also found that anti-terrorism action had a distinct moderating effect on the "terrorism attacks – trade efficiency" causal chain. Li and Yan [11] used the gravity model to investigate the impact of terrorist attacks on the imports and exports of countries along the "One Belt One Road" routes. According to this study, terrorist attacks have a less negative impact on trade between China and the countries along these routes than they do on trade with other countries. This may be a beneficial effect of China's foreign policy of peaceful coexistence and non-interference in the internal affairs of other countries. Azhati and Jiang [12] studied the impact of terrorist threats in some countrieson China's exports: it was found that the number of terrorist attacks and the number of casualties had a significant impact on exports. Zhang and Zhang [13] studied the trade-isolation effect of the risk of terrorist activity: increased terrorist risks in a country will produce a significant "trade-isolation effect", reflected mainly by a significant decrease in a country's export dependence. Moreover, the "trade-isolation effect" also relates to the heterogeneity of the target, and the degree of "trade-isolation effect" positively correlates with the randomness of the target. Xu and Liu [14]studied the impact of terrorist activities on the export of tourism service trade in the local and surrounding areas. The direct effect, the spatial spillover effect, and the total effect of terrorist activities on the development of tourism are all negative, and the spillover effect is greater. In other words, terrorist activities not only inhibit the development of tourism in those countries attacked, but they also have a negative impact on tourism in geographically and culturally similar countries through the spillover effect. The studies focus on the impact of terrorist attacks on trade, including trade in goods and services. Generally, the research results all point to the negative impact of terrorist attacks on the trade of imported and exported goods or services.

2.2 The Investment Effect of Terrorist Attacks

The first strand of literature we are reviewing focused on the effect of terrorist attacks on both FDI and OFDI. Lanouar and Shahzad [15] studied the impact of such attacks on foreign investment in large cities. Through a sample study of seven South Asian countries, they found that terrorist attacks in large cities hurt FDI. For every 1% increase in terrorist attacks, there was a significant decrease in FDI of 25.4%. Additionally, the study found that terrorist attacks in large cities had a greater adverse impact on external debt stocks and government lending than full-scale terrorist attacks. This study mainly focuses on the relationship between terrorist attacks in big cities and the FDI of Southeast Asian countries, and finds that attacks in big cities are the main obstacle to capital flow in South Asian countries.

Enders and Sachsida used two different estimation methods to measure the impact of terrorist attacks on FDI in a certain country. The results show that attacks have a significantly negative impact on FDI in the short term. Specifically, if the frequency of terrorist attacks increases by 1%, FDI in a developed country will decrease by 1.6%. However, the effect is not significant in the long term. The results show that whilst terrorism continues to hurt the American economy, the impact is limited. Tomislav [1] studied the impact of terrorist attacks on capital flows (including FDI inflows and FDI outflows) in developed countries. The results showed that a 1% increase in terrorist attacks would significantly decrease the FDI inflows per capita by 0.0001%. They also indicate a negative correlation between capital flow and terrorist attacks in developed countries. However, the occurrence of terrorism in developed countries does not strongly impact the outflow of FDI. Meanwhile, terrorist attacks may have a positive impact on capital flows, such as in the manufacturing of guns and military equipment.

Zhang and Sun [16] studied how terrorist risks in neighboring countries affected China's OFDI. They found that a 1% increase in the frequency of terrorist activities in the host countries led to a 1.496% decrease in the stock of China's OFDI in the host country. It also found that increasing international trade between China and the host country can effectively mitigate the risk of terrorist activities, thus mitigating the negative impact on China's OFDI.

The second strand of literature focuses on the mechanism of terrorist attacks affecting foreign investment. According to studies by Liu and Chen , there are three mediating mechanisms for the impact of a terrorist attack in Country A on the OFDI of Country B. The first mechanism is the talent-loss effect. When there is a terrorist attack in Country A, the health of enterprise employees and the safety of property in Country B will be greatly threatened. In order to avoid increasing losses, enterprises in Country B will not enter the market of Country A, thus reducing the capital inflow of Country A. The second mechanism is the cost effect. When terrorism prevails in Country A, the enterprises of Country B need to spend a lot of money on insurance in order to protect their property security in Country A, thus increasing their operating costs. Therefore, enterprises from Country B are more likely to withdraw from the market of Country A, thus reducing the capital inflow of Country A. The third mechanism is the accumulation of panic. A terrorist attack in Country A will lead to social unrest in Country A, resulting in economic disorder and a decline in domestic demand. All these factors will reduce the attraction of Country A to foreign investors.

Existing studies generally include analyses of the impact of terrorist attacks on domestic economic development and international trade cooperation, as well as on foreign investment. However, such studies primarily focus on the West, including America, Europe, North Africa, and the Middle East, whilst terrorist threats in Central Asia, South Asia, and Southeast Asia are rarely mentioned. Considering the particularity of different regions, the above results may not be completely consistent with the study of terrorist threats in these regions.

Existing research on the trade impact of terrorist attacks mainly takes western countries or countries around China as a

sample. There are few studies focusing on terrorist attacks actually within China. In particular, there is no study assessing the impact of terrorist attacks in the cities in China where such attacks took place. This is partly because the number and scale of domestic terrorist attacks in China is relatively small and the economic impact is not obvious. However, if we only focus on a city or region where terrorist attacks once occurred, it will be found that violent terrorist attacks still have a relatively distinct impact on the indicators of a certain region.

3 DATA AND EMPIRICAL STRATEGY

3.1 Data Description

This study uses panel data from prefecture-level cities in the China City Statistical Yearbook, with cities in central and western provinces as potential control groups. Cities in Xinjiang, Tibet, Gansu, Qinghai, Ningxia, and other remote provinces/autonomous regions are excluded due to missing FDI data. Finally, a total of 127 valid sample cities was obtained.

The study uses FDI as the research objectand uses urban GDP, population, the proportion of tertiary industry in GDP, the total output value of Hong Kong, Macao, and Taiwan Investment Enterprises above the designated size and finally, the total output value of FIEs above the designated size as the prediction variables. We use the SCM and empirical analysis with the STATA software synth program.

3.2 Setting of Synthetic Control Method (SCM)

3.2.1 Counterfactual analysis introduction

The counterfactual analysis is represented by Rubin [17]. In short, to evaluate the effect of a policy/event on region "*i*" (assuming that we are concerned about the impact of the event on the "*Y*" of region "*i*"), it is intuitive to observe the time series data of "*Y*" and compare the changes of "*Y*" before and after the time point of the event. However, this change is easily interfered with by the environment. "*Y*" may be affected by other environmental factors, thus the difficulty in proving this change has a causal relationship with a policy/event.

The framework of counterfactual analysis attempts to explore the causal relationship between the event and the "*Y*" index of region "*i*" as follows: if we assume that the event did not occur in region "*i*" in the "*t*" period, then what would be the "*Y*" of region "*i*" in the (*t*+1) period? Secondly, if the event did occur in the "*t*" period, then what would be the actual level of "*Y*" in the (*t*+1) period and beyond? The difference between the two is not only the actual impact of the event, but also the causal effect.

The mathematical model can help to express this idea: if "*D*" indicates an event, then whenever D_i= 1, it occurred in area "*i*", and when D_i = 0, the event did not occur in area "*i*". Then, when D_i= 1, Y_i= $Y_{1,\ i}$. Furthermore, whenever D_i = 0 and Y_i = $Y_{0,\ i}$, under this framework, the causal effect of event "*D*" on region "*i*" can be recorded as follows: $\tau = Y_{1,i} - Y_{0,i}$.

However, $Y_{0,\ i}$ cannot realistically be observed in "*i*" area where "*D*" event happened due to inconformity. This is also the origin of the term "counterfactual framework". As an alternative, we can look for another area which is highly similar to area "*i*" in all aspects. It has no "*D*" event and can be used as a substitute for area "*i*" ("if it is not affected by the event"). The estimated causal effect can be obtained by observing the difference between the treatment group "*i*" and the control group where "*i* was not affected by the event" after event "*D*". The next section explores the SCM, and will consider the method to find a good "stand-in".

3.2.2 Overview of Synthesis Control Method (SCM)

Abadie [18] put forward the SCM throughout his time studying the influence of terrorist activities on the economic indicators prevailing in a certain country in the 1970s. Based on the "counterfactual analysis framework", this method designs a set of methods to discover the best substitute , which is the control group of region "*i*" to compare the situation difference between region "*i*" and the control group after event "*D*".

Basically, this study aims to construct the "Synthetic Kunming" that is most similar to the real Kunming. It is necessary to find an optimal linear combination amongst cities in China, many of which may be similar to Kunming.

We suppose that there are (*1*+ *J*) cities in the database, the first being Kunming, which has suffered terrorist attacks. The remaining "*J*" cities have not been subjected to terrorist attacks. To construct this linear combination, we need to consider how to allocate the weight of each city in the combination. It is worth noting that weight "*W*" is the J-dimensional column vector (w_2, w_3, $w_{j+\ 1}$), whereby w_j is the weight of the *j-th* city in the synthetic control area, all weights are non-negative, and the sum is 1.

In this study, the dependent variable is "*y*" (FDI). Other indicators related to "*y*" can be used as predictors to help investigate the similarity between other cities and Kunming and to construct a control group. A record is compiled of the average value of each forecast variable in Kunming before the event in 2014, as vector x_1 (*K*1* column vector, representing the value of "*K*" forecast variables in Kunming), and we note that the average value of each prediction variable of other "*J*" cities is the matrix X_0 (*K*J* matrix, which represents the value of "K" prediction variables of "*J*" cities).

The goal of selecting weight "*W*" is to make X_0W as close to x_1 as possible. Additionally, since each predictor variable has a different degree of influence on "*y*", the predictor variables in x_1 should also be given different weights. Each number on the diagonal in the *K*K*-dimensional diagonal matrix "*V*" corresponds to a non-negative weight of different predictive variables. The following constrained minimization problem aims to find a suitable "*W*":

$$\min_{W}(x_1 - X_0 W)'V(x_1 - X_0 W)$$
$$st.w_j \geq 0, j = 2,3,...,J+1; \sum_{j=2}^{J+1} w_j = 1 \quad (1)$$

In the above problem, we can find the optimal solution "W", where the solution of "*W*" depends on the diagonal matrix "*V*", which can be denoted as *W**(*V*). Thus, as long as we find the optimal "*V*", we can obtain the optimal weight "*W*".

To identify the optimal "*V*", we need to make the FDI of the control group of other cities before 2014 as close as possible to that of Kunming. We record FDI in Kunming in each year before 2014 as the vector z_1 (*T*1* column vector represents FDI in Kunming in the "*T*" years before 2014). We record the FDI of the other "J" cities in each year as the matrix Z_0 (*T*J* matrix, representing FDI of "*J*" cities in "*T*" years). Similarly, $Z_0W^*(V)$ should be close to z_1. The logic to minimize the mean square prediction error is as follows:

$$\min_{V} \frac{1}{10}\left(z_1 - Z_0 W^*(V)\right)'\left(z_1 - Z_0 W^*(V)\right), \text{ where "V" is not negative.} \quad (2)$$

The optimal weight *W** can be obtained by solving the minimization problem of (2). Observation of the differences after 2014 enables us to construct the "Synthetic Kunming" with the best weight *W**, which is indeed highly similar to the real Kunming.

4 EMPIRICAL ANALYSIS

4.1 Descriptive Analysis

According to existing literature on terrorism economics, a major terrorist attack in an area has a negative impact on economic activity in that area, including disrupting trade or investment confidence, and even affecting overall regional economic growth.

In order to explore whether this negative effect existed in Kunming after the terrorist attacks, we make a descriptive statistical analysis of the GDP growth rate and the actual amount of FDI in Kunming both before and after 2014.

Figure 1 shows that the GDP of Kunming (the whole city) maintained rapid growth from 2010 to 2013, with the highest growth rate of 14.1% in 2012. However, in 2014 when the terrorist attack on "3.01" occurred (the year marked by the vertical dotted line in Figure 1 below), the GDP growth rate of Kunming dropped significantly compared with that of the previous year, and reached its lowest point of 8% in 2015. The growth rate picked up slightly in 2016. The apparent decline in this indicator (GDP growth rate) happened in the same year as the terrorist attacks.

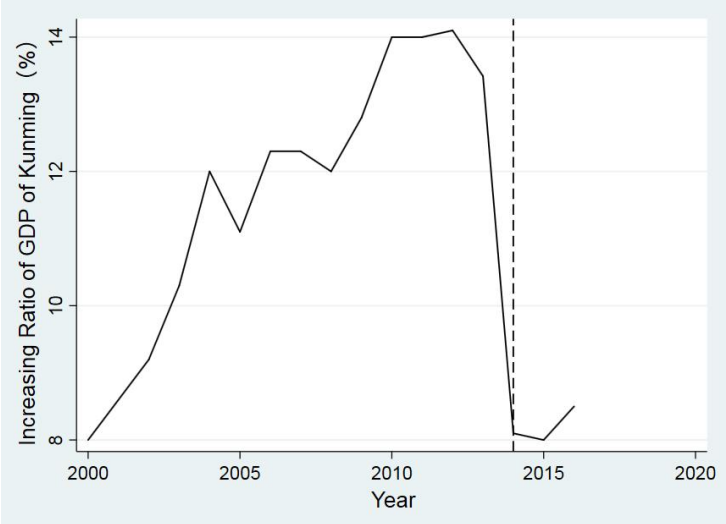

Figure 1 GDP Growth Rate of Kunming from 2000 to 2016

In addition to GDP growth, FDI is also vulnerable to terrorist attacks, since stability and security in a region affect the business environment due to the risk and return of investment. A major security incident in a region will cause panic amongst investors or potential investors in that region, cause increased anxiety among investors about terrorist attacks and uncertainty about the psychological need to continue investing in the city, leading to a decline in FDI.

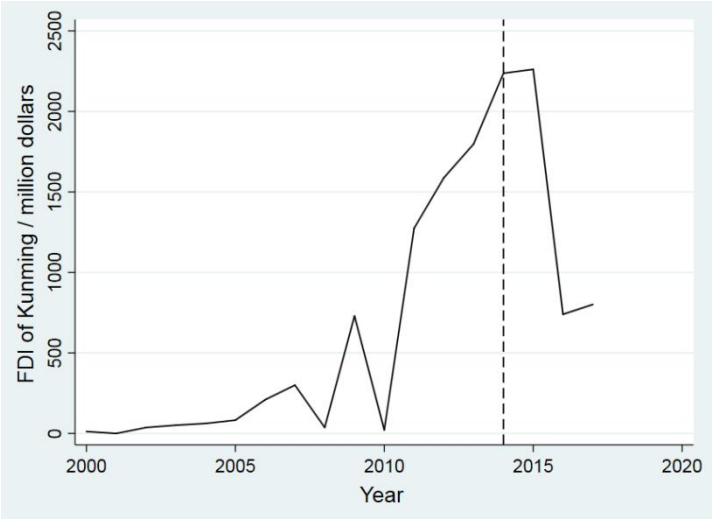

Figure 2 Foreign Direct Investment in Kunming from 2000 to 2017

Figure 2 shows that FDI in Kunming maintained a considerable growth rate from 2010 onwards, reaching $2.237 billion in 2014. Nevertheless, the terrorist attacks in 2014 caused the FDI in 2015 to have a very slight growth of $2.261 billion, almost the same as the previous year, whilst 2016 onwards saw a significant decline. Thus, we can predict that the terrorist attack in 2014 may have had a negative impact on foreign direct investment in Kunming. This negative effect has a certain delay. Due to historical inertia, FDI growth stagnated in 2015, but in 2016 FDI experienced a huge decline.

4.2 Empirical Results of Synthetic Control Method (SCM)

This study selects the period from 2002 to 2017, and takes 2014 as the starting year of event intervention. The following are specific forecast variables: total population at the end of the year; non-agricultural population; proportion of employees in tertiary industry; land area of administrative region; population density; GDP and per capita GDP; GDP growth rate; proportion of tertiary industry in GDP; output value of Hong Kong, Macao, and Taiwan/foreign-funded enterprises above Designated Size; net value of fixed assets; investment in fixed assets; completed investment in real estate development; retail sales of social consumer goods; local general public budget revenue. All the data are city-level data, except for the local general public budget revenue that is municipal district data. Additionally, we refer to Abadie (2010) to select the predictive variables for studying the effectiveness of the California Tobacco Control Act. We add FDI in 2002, 2008 and 2013 as three additional predictive variables, which are the starting year, the year of the global financial crisis, and the year before the "3.1" terrorist attack, respectively. This reduces the impact of special values in individual years.

4.2.1 The weight of each city in "Synthetic Kunming"

According to the results of the synth program, the cities that contribute to the economic situation of Kunming are not 0, and are as follows:

Table 1 Weight in the Cities in "Synthetic Kunming"

City	Guiyang	Zhengzhou	Luoyang	Harbin	Chengdu	total
Weight（%）	58	25.6	8.1	6	2.3	100

Data source: https://www.gtarsc.com/

As shown in Table 1, most of the cities contributing to "Synthetic Kunming" are provincial capitals in the central and western regions of China. In line with general expectations, Guiyang, which is similar to Kunming, has the highest weight.

4.2.2 Analysis of synthetic control results

We draw the change trend of FDI in "Synthetic Kunming" and the real Kunming City during the study period as a line chart, and then compare them in the same chart to get the synthetic control effect.

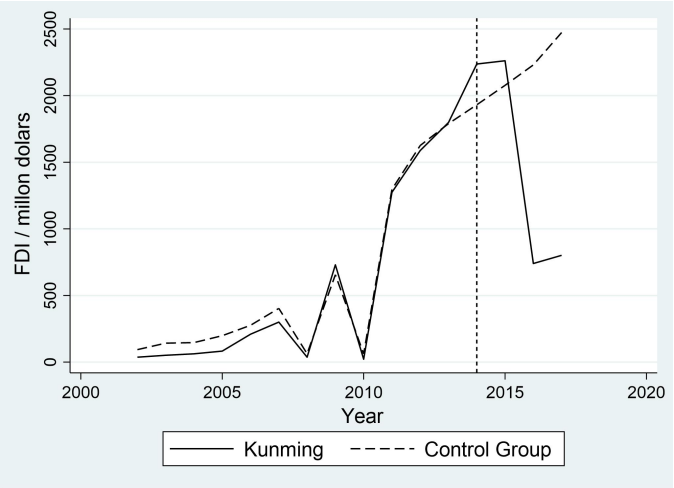

Figure 3 Diagram of Synthesis Control Effect

In Figure 3, the year of the "3.01" terrorist attack in Kunming in 2014 is marked with a vertical dotted line. The black solid line represents the real change in FDI in Kunming from 2002 to 2017, whilst the dotted line represents the changingtrend of FDI in "Synthetic Kunming", synthesized by the five cities in Table 1.

It can be seen that the two curves were very close before 2014, indicating that "Synthetic Kunming" had a good fitting effect on the real Kunming. From 2015 to 2017, the actual FDI of "Synthetic Kunming" maintained a considerable growth rate, which was close to US $2.5 billion in 2017. However, the actual FDI in real Kunming stagnated in 2015 and fell in 2016, producing a huge disparity with "Synthetic Kunming" in the last two years of the study period. This demonstrates an obvious causal relationship between the terrorist attacks in 2014 and the decline of FDI in Kunming, with a one-year delay in the occurrence of this negative effect.

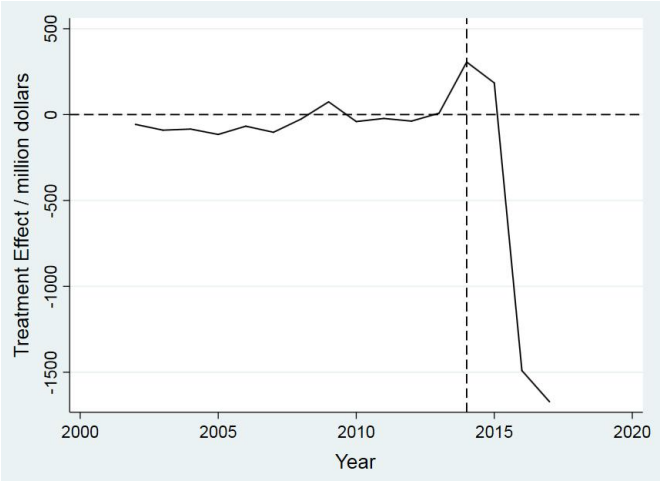

Figure 4 Effect of Synthetic Control Treatment in Kunming City

We get the treatment effect by subtracting the actual FDI in "Synthetic Kunming" from the actual FDI in real Kunming. Figure 4 shows the treatment effect. It can be seen that the processing effect fluctuated at around 0 before 2014. After 2014, especially in 2016 and 2017, the treatment effect then showed an obvious negative value, indicating the huge negative effect of the "3.01" terrorist attack in Kunming. The treatment effect in 2016 was US $-1.49 billion, which means that Kunming lost 66.62% of actual FDI in 2015 and 2016 compared with 2014.

4.2.3 Robustness test of synthetic control results

In order to test the validity and robustness of the above results, this section uses the "Placebo test" method proposed by Abadie (2010). The idea of the "Placebo test" is as follows: in order to test whether the negative treatment effect of Kunming may be caused by accidental or other factors, we must investigate whether a city is randomly selected from a potential control group, such as the "Hypothetical Treatment Group", and we suppose that it also had a terrorist attack in 2014, according to the SCM for Kunming. This will enable us to decide if we should give it the same treatment and investigate whether there will be similar negative effects. If a series of "Hypothetical Treatment Groups" are selected, the treatment effect is not as great as the huge negative value of Kunming, and it can then be considered that the negative treatment effect of Kunming after 2014 is significant and robust.

In order to avoid subjective arbitrariness in the extraction of the "Hypothetical Treatment Group", we take the actual FDI of Kunming in 2014 as the standard and select those cities where the actual FDI in 2014 is between a quarter and four times that in Kunming as the "Hypothetical Treatment Group" (If the difference between the actual FDI of the

"Hypothetical Treatment Group" and that of Kunming is too large during the investigation period, it has little reference value). The setting of this interval also includes all those cities whose weight in terms of "Synthetic Kunming" is not 0. These cities are then synthetically individually controlled to obtain their treatment effect.

It should be emphasized that if the MSPE (Mean Square Prediction Error) of the synthetic control of the "Hypothetical Treatment Group" is too large, the fitting effect is not ideal and its treatment effect cannot be used as a reference. The STATA synth program reports the RMSPE (Root Mean Square Percentage Error) of the synthesis control. According to this index, this study eliminates those cities whose MSPE was twice as large as that reported in the synthetic control treatment of Kunming, finally retaining 22 effective "Hypothetical Treatment Groups".

We plot the treatment effect curves of these "Hypothetical Treatment Groups" and the treatment effect curves of Kunming City in the same graph. Thus, we can directly compare their treatment effects.

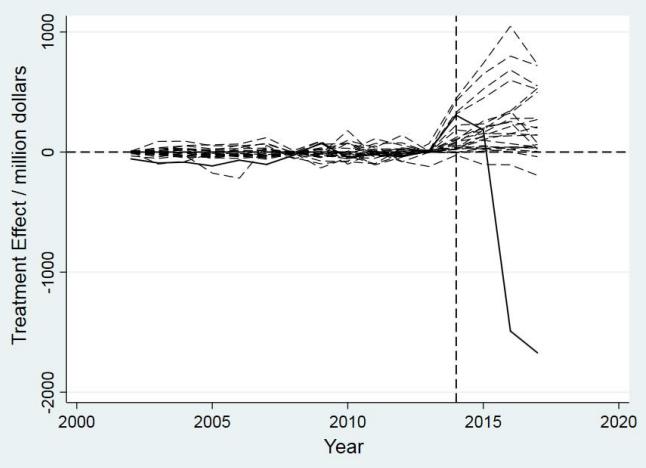

Figure 5 Placebo Test

In Figure 5, the black solid line is the treatment effect curve of Kunming City, whilst the other dotted lines are the treatment effect curves of 22 "Hypothetical Treatment Groups". Before 2014, the treatment effect curves of all cities fluctuated at around 0, indicating that the "Hypothetical Treatment Group" had a good fitting effect when we retained those cities whose MSPE was within less than twice the MSPE of Kunming. After 2014, the treatment effect curve of Kunming is far lower than that of all other cities.

Amongst the 23 cities, Kunming has the most significant negative treatment effect at only 4.35%, which is less than the general significance level. Therefore, it can be considered that the huge negative treatment effect of Kunming City is not caused by accidental factors and that this result is significant and robust.

5 THE MECHANISM OF THE DECLINE OF FOREIGN DIRECT INVESTMENT (FDI)

The synthetic control methods test enables us to determine that the terrorist attacks in Kunming in 2014 had a negative impact on its FDI. According to the treatment effect, the estimated decrease in FDI caused by the "3.01" attack is about 66.62%. However, the specific mechanism of this negative effect is not clear.

This section aims to explore the specific mechanism of the decline in FDI as a result of terrorist attacks.

5.1 Terrorist Attacks May Affect Local Economic Growth

In the field of terrorism economics, researchers generally believe that terrorist attacks will have a negative impact on regional economic growth.

Figure 1 shows that the growth rate of Kunming's GDP in 2014 dropped significantly compared with 2013, and there was no rebound in the short term (see the solid line in Figure 6). At the same time, Figure 2 reflects the decline in FDI in Kunming after 2014. This decline occurred in 2016 after the terrorist attacks, with a certain time lag (see the dotted line in Figure 6).

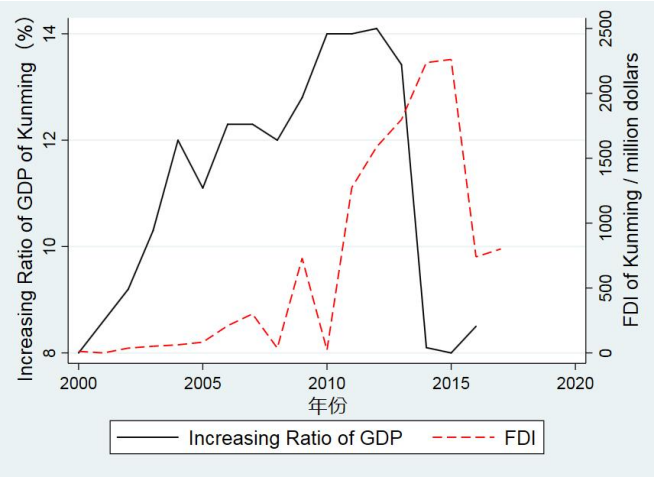

Figure 6 Comparison of GDP Growth Rate and FDI in Kunming

In Figure 6, the two curves are drawn on the same graph to compare the growth rates of GDP and FDI in Kunming. The solid line is the GDP growth rate curve, the dotted line is the FDI curve. We can see that the trend of the two curves is highly similar: the FDI curve (dotted line) has about two periods of delay compared with the GDP growth rate curve (solid line). For example, the growth rate of GDP reached a low point in 2008, followed by FDI reaching a low point in 2010. The GDP growth rate dropped sharply in 2014, followed by a sharp drop in real FDI in 2016.

This phenomenon shows that the terrorist attacks may have had an immediate impact on the local GDP growth rate with a delayed impact on FDI. Foreign investors show negative sentiments for a longer period of time, with impaired economic perception norms, leading to weakened trust in the city and in the community and hesitation to continue investing in the city. This also explains why the negative impact of terrorist attacks on FDI will be delayed for one to two years.

5.2 Terrorist Attacks May Affect the Behavior of Economic Entities

In addition to the macro impact, terrorist attacks also have a micro impact. After a local terrorist attack, residents (consumers) and enterprises (producers) may reduce their economic activity because of a fear of unsafe factors. Testing whether terrorist attacks reduce the participation of residents and enterprises in economic activities can prove whether or not terrorist attacks cause panic at the micro level. Furthermore, it can be predicted that foreign investors are facing the same panic as domestic residents/enterprises. Because the flight or transfer of foreign capital is more flexible than that of local residents/enterprises, a decrease in relevant economic indicators caused by panic will be more obvious.

5.2.1 Mechanism test based on consumer behavior

After the terrorist attacks, the local residents in Kunming may have had a fear of unsafe factors, which may have reduced their consumption activity in terms of entertainment, catering consumption, and so on. In addition, the recent terrorist attacks may have reduced the willingness of residents outside the city and province to travel to Kunming.

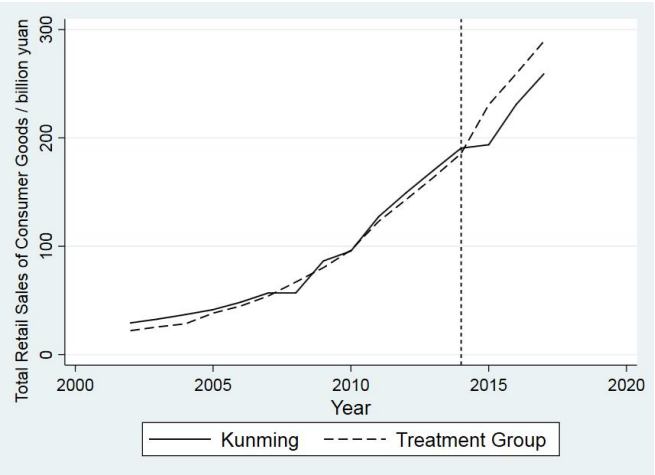

Figure 7 Synthetic Control Effect of Retail Sales of Social Consumer Goods in Kunming

In order to test whether consumer behavior is negatively affected by the terrorist attacks, we select the retail sales of social consumer goods in Kunming as the proxy index of consumer consumption activity and also use the idea of synthetic control methods to test the effect. Figure 7 shows that prior to the terrorist attacks, the curve of the retail sales of social consumer goods in Kunming was basically consistent with the synthetic curve, with good fitting effect.

However, following the terrorist attacks, the real retail sales of consumer goods in Kunming City (the solid line) stagnated for one year and returned to their normal growth rate two years later. However, there was some difference when comparing with the synthetic region (after 2015, the two curves in the figure extended almost in parallel and the solid line was below the dotted line). This shows that consumer behavior has been negatively affected by the terrorist attacks, increased consumer anxiety and negative feelings about spending money in that city, with a more immediate effect than that on FDI, but that the impact period is shorter and the impact effect is lower.

5.2.2 Mechanism test based on enterprise behavior

Similarly, the short-term panic caused by terrorist attacks existed not only in the consumer groups, but also amongst the producers/investors. Enterprises that had the intention of investing may have delayed their investment plans in Kunming, or switched to investing outside the city/province, as a result of the recent terrorist attacks.

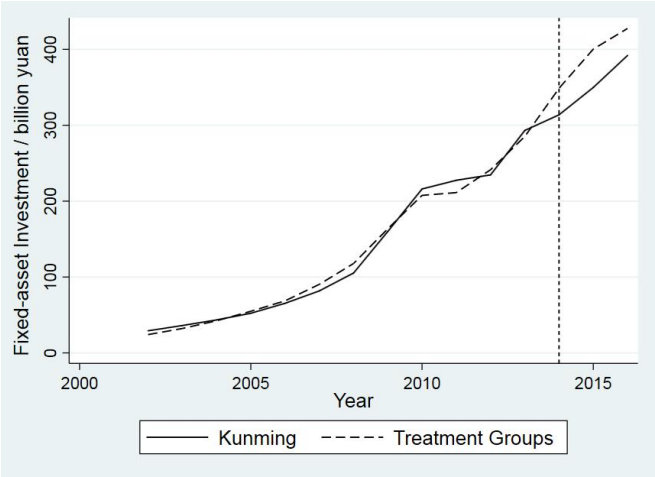

Figure 8 Effect of Synthetic Control of Fixed-Asset Investment in Kunming City

We take the total fixed-asset investment in Kunming as the proxy index of enterprise participation in local economic activities in the city and use the idea of synthetic control methods to test the effect. Figure 8 shows that after the terrorist attacks, Kunming's total fixed-asset investment deviated significantly from the synthetic area and the treatment effect was negative. This shows that the total investment in fixed assets in Kunming was also negatively affected by the terrorist attacks. This is similar to the change in the retail sales of social consumer goods and the short-term effect is weaker than that of FDI.

Overall, the terrorist attacks in Kunming in 2014 did have a negative impact on the participation of economic entities in economic activities and the panic and anxiety may have been widespread. Compared with the effect on FDI, this kind of influence has a more immediate response, a shorter influence period, and a weak influence effect.

6 CONCLUSION AND POLICY SUGGESTIONS

The impact of terrorist activities on international trade, tourism consumption, and foreign capital flow is highly debated within the international economic community. This study focuses on terrorist attacks in China, taking the attacks in Kunming in 2014 as an example to study the impact on FDI in Kunming, a subject that has so far attracted little attention in academic research. This study collects and collates relevant economic data from more than one hundred prefecture-level cities in central and western China, and uses the SCM (Synthetic Control Method) to study whether or not the terrorist attack in Kunming in 2014 caused the decline in FDI in the following two to three years.

The result shows that "Synthetic Kunming", which is the control group made up of other prefecture-level cities, has a good fitting effect on Kunming City through the SCM and that the change trend of FDI in the synthetic control group is basically the same as that in the real Kunming City before 2014. Following 2014, there was a huge deviation in FDI between the real Kunming and "Synthetic Kunming". In other words, FDI in "Synthetic Kunming" continued to grow at a considerable speed, whilst FDI in real Kunming stagnated in 2015 and dropped dramatically in 2016. This indicates that the violent terrorist attack in 2014 did lead to the decline of FDI in Kunming and that the negative impact had a time lag of about one year. This indicates a longer duration of negative emotions of fear expressed by foreign investors, a weakening of investment in the city, as well as an erosion of perceived economic norms, a decrease in the credibility of the city, and a hesitation to continue investing in the city. In the robustness test, we employed the "Placebo test" method to conduct the same synthetic control study and used 22 cities outside Kunming as the control group. We found that the treatment effect of Kunming was significantly lower than that of the other 22 cities after 2014, demonstrating that the negative impact of the terrorist attacks on the FDI of Kunming was robust.

The study further discusses the specific mechanism of the decline in FDI in Kunming caused by terrorist attacks at both the macro and the micro level. At the former level, it is found that terrorist attacks can reduce economic growth rate and deter foreign investment. At the latter level, it is found that terrorist attacks caused economic entities to reduce their participation in economic activities in the region. Specifically, the retail sales of social consumer goods and the total investment in fixed assets in Kunming, caused growth stagnation or delay by one or two years after 2014. This shows

that terrorist attacks have a negative impact on the participation of micro economic entities in economic activities. This is indicative of increased anxiety among consumers and investors about the continuation of terrorism and uncertainty about psychological needs.

Our study generates practical implications for reducing terrorist attacks and their economic effects. Firstly, it is important to prevent the risk of terrorism before the event. China should adhere to the path of peaceful development, which includes non-interference in the internal affairs of other countries, no riot spreading, and instead maintain a peaceful, friendly, and responsible image. At the same time, China should eliminate poverty and reduce income differentiation, in the pursuit of equality, unity, and prosperity amongst all ethnic groups. Moreover, China should respect the customs and religious beliefs of minority peoples and their languages and cultures.

Secondly, it is vitally important to reduce the harm caused by terrorist activities. In order to minimize resident panic at the micro level, the following are necessary: immediate report of the actual situation of the terrorist attack; immediate dispatch of police to control mobs and their accomplices; timely eradication of the event planners; conveyance of all this information to the public. The early resolution of panic is conducive to the timely recovery of normal economic activities. For local enterprises or foreign-funded enterprises that have suffered losses in terrorist attacks, the government can give appropriate compensation or produce preferential policies conducive to resuming production, so as to boost production enthusiasm and investment confidence. At the international level, it is important to carry out anti-terrorism cooperation with neighboring countries to prevent terrorists from hiding abroad. It is equally necessary to globally convey true and transparent information about the attack, and the measures taken to deal with it in a timely fashion, as this is conducive to the timely resolution of foreign capital outflow.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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THE INTEGRATION MECHANISM BETWEEN CARBON TRADING MARKET AND DUAL-CONTROL OF CARBON EMISSIONS: A CASE STUDY OF SHENZHEN

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Abstract: Global warming and the imperatives of low-carbon development have driven the implementation of China's carbon peak and carbon neutrality goals. This paper takes Shenzhen as a case study and constructs an analytical model from the perspectives of institutional economics, policy integration, and multi-level governance. Utilizing policy text analysis and qualitative research methods, it examines the linkage between the carbon trading market and the dual-control mechanism for carbon emissions. The findings indicate that the synergistic effect of market incentives and administrative regulation significantly promotes carbon reduction and provides valuable insights for low-carbon transformation. This study enriches the theoretical framework of carbon governance and offers decision-making guidance for China's low-carbon transition, with substantial potential for both theoretical advancement and practical application in policy implementation.
Keywords: Carbon trading; Dual-control mechanism; Shenzhen model

1 INTRODUCTION

Global climate change is becoming increasingly severe, and the frequent extreme weather events triggered by greenhouse gas emissions pose serious challenges to global ecological security and the development of human society[1]. In response to this global issue, the international community has been continuously strengthening low-carbon governance and sustainable development strategies. In recent years, under the dual pressures of international emission-reduction commitments and domestic resource and environmental constraints, the Chinese government officially proposed the "30·60" dual carbon goals in 2020—aiming to achieve peak carbon emissions by 2030 and carbon neutrality by 2060[2]. This strategic deployment not only demonstrates China's commitment to global climate governance but also provides guidance for exploring a low-carbon development pathway domestically.

In the process of promoting low-carbon transformation, market-based instruments and government regulation are two complementary governance mechanisms. At the end of 2011, China launched a pilot project for carbon emission trading in the "two provinces and five cities," among which Shenzhen—being one of the pilot cities—took the lead in developing its carbon trading market[3]. As a forefront of reform and opening-up and a demonstration zone for low-carbon governance, Shenzhen has formed a unique and representative governance model for carbon emission control, leveraging its economic vitality and policy innovation capabilities. In 2013, Shenzhen officially initiated its carbon emission trading pilot, covering approximately 40% of the city's total carbon emissions[4]. According to statistics, among the 636 enterprises participating in trading in 2015, total CO_2 emissions decreased by 5.31 million tons compared to 2010, and carbon intensity fell by 41.8%—significantly exceeding the national target of a 21% reduction in the same period. This series of practices fully demonstrates that the carbon trading market plays a significant role in stimulating enterprises' energy conservation and emission-reduction initiatives and in promoting the transformation to a low-carbon economy.

However, relying solely on market mechanisms is insufficient to achieve deep-level emission reduction goals. Although the traditional "dual control of energy consumption" policy has achieved certain results in controlling both total energy consumption and energy intensity, its approach to addressing carbon emissions is gradually shifting toward a more stringent "dual control" model. Shenzhen was the first in the country to establish and implement a dual-control system for carbon emissions, providing valuable experience for the transition from energy consumption dual control to carbon emission dual control in Guangdong Province and nationwide. Therefore, constructing an effective linkage mechanism between the market-oriented carbon trading mechanism and the government-led dual-control policy for carbon emissions has become an urgent theoretical and practical issue in the field of low-carbon governance.

This study aims to construct a comprehensive theoretical analysis framework—drawing on perspectives from institutional economics, policy integration theory, and multi-level governance theory—to conduct a qualitative analysis of the linkage mechanism between Shenzhen's carbon trading and dual-control policies for carbon emissions. By systematically reviewing Shenzhen's policy documents over the years and incorporating simulated expert interview data, this paper seeks to reveal how market mechanisms and government intervention can achieve effective synergy in carbon governance. The innovations of this research include:

(1) integrating multiple theoretical perspectives to construct an analytical model that transcends the limitations of a single theoretical framework;
(2) combining qualitative research methods with policy document analysis to address the deficiencies in previous quantitative studies in capturing the nuances of policy content; and
(3) using the case of Shenzhen—an international metropolis—to provide valuable experiences for carbon governance in other regions and internationally.

2 LITERATURE REVIEW

2.1 Current Research on Carbon Trading and Dual-Control Policies at Home and Abroad

2.1.1 Carbon trading market research

Carbon emission trading (ETS) is the core market-based tool for emission reduction and has been widely studied both internationally and domestically. Developed economies in Europe and America established carbon markets earlier and accumulated rich experiences. The European Union launched the world's first large-scale carbon emission trading system (EU ETS) in 2005, covering the power and heavy industry sectors, and has undergone several phases to improve quota allocation and cross-border trading mechanisms. Research indicates that the EU ETS has led to a cumulative reduction of about 41% in carbon emissions from regulated industries, demonstrating the effectiveness of this market tool in large-scale emission reduction[5]. Although the United States has not implemented a nationwide carbon market, regional pilots have been carried out at the state level, such as the Regional Greenhouse Gas Initiative (RGGI) in the Northeast and the California carbon trading system[6]. These markets have also achieved remarkable results—for example, the RGGI power sector saw an average annual emission reduction of about 48% between 2006–2008 and 2016–2018, significantly outpacing the national average reduction rate[7]. Domestically, China began exploring the carbon market mechanism around 2011, launching pilot carbon emission trading projects in Beijing, Shanghai, Shenzhen, and other regions, and established a national carbon market in 2021. The Chinese carbon market has a broad coverage, initially dominated by the power generation sector (accounting for about 40% of the country's carbon emissions); it is expected to eventually cover over two-thirds of national carbon emissions. Research results show that the pilot carbon trading policies in China significantly reduced carbon emissions in the pilot regions by approximately 6.2%[8]. In Shenzhen, as one of the first pilot cities, the carbon emissions of 636 regulated enterprises decreased by 18.2% between 2010 and 2015[9]. Scholars have also focused on issues in the design and implementation of carbon market mechanisms, such as surplus allowances, low carbon prices, and limited industry coverage[10-12]. Overall, both domestic and international literature affirm the role of carbon trading markets in promoting cost-effective emission reduction and stimulating low-carbon technological innovation, and provide empirical evidence for improving market mechanisms.

2.1.2 Dual-control policy research on carbon emissions

"Dual control of carbon emissions" is a novel governance policy proposed by China under the constraints of the "carbon peak and carbon neutrality" goals, which entails simultaneously controlling the total amount and intensity of carbon emissions. Its conceptual origin can be traced back to China's long-standing "dual control" policy on energy consumption—that is, imposing dual constraints on total energy consumption and energy intensity[13]. Since the 13th Five-Year Plan period (2016–2020), China has begun to allocate energy consumption dual-control targets according to provincial administrative regions, assessing local energy intensity reduction rates and total energy consumption. Research has shown that this measure effectively curbed the growth of high energy consumption, with energy consumption per unit of GDP continuously declining and carbon emission intensity decreasing by about 34% over ten years[14]. However, dual control of energy consumption focuses on energy usage and does not directly target carbon emissions. With the rapid development of renewable energy and the advancement of the "carbon peak and carbon neutrality" strategy, its limitations have become increasingly apparent. For instance, in order to meet energy consumption targets, some regions have implemented rough measures such as power restrictions, and the increase in renewable energy might be constrained since it is included in total energy consumption[15]. In view of this, both academia and policy circles have recently shifted their focus to exploring the transition from dual control of energy consumption to dual control of carbon emissions. The dual control of carbon emissions—by focusing on controlling fossil fuel consumption—will better stimulate the development of renewable energy and precisely serve the goals of carbon peaking and carbon neutrality[13].

Current research has begun to focus on the institutional design and impact assessment of carbon dual-control policies. For example, by comparing and simulating the dual control of energy consumption with carbon dual control policies to evaluate their effects on the economy and emission reductions, results indicate that both policies can effectively reduce carbon emissions and optimize the energy structure, but carbon dual control has advantages in guiding low-carbon technology investments and avoiding unnecessary constraints on renewable energy[16].

Internationally, although climate governance frameworks such as those adopted by the European Union do not explicitly propose "dual control," they do encompass similar ideas—for instance, the "20-20-20" strategy includes both greenhouse gas reduction targets and energy efficiency improvement targets, which essentially constitutes a comprehensive policy toolkit that simultaneously pursues total control and intensity improvement[17]. This indicates that carbon dual control has a certain universal significance, but its systematic implementation is still mainly taking place in the Chinese context, and related academic research is in its early stages.

2.2 Theoretical Perspectives and Case Analysis on the Combination of Market Mechanisms and Government Intervention

In the field of low-carbon governance, market mechanisms (such as carbon trading) and government intervention (such as administrative dual control) are not in opposition but rather mutually complementary. The theory of institutional economics points out that the effective functioning of markets depends on the government establishing clear property rights and institutional foundations[18]. Carbon trading essentially involves the government setting carbon emission quotas as property rights and allowing their trading—thereby internalizing externalities in accordance with the Coase theorem; meanwhile, the government ensures market operation through laws and regulations, reducing transaction costs and information asymmetry, thus enhancing the efficiency of resource allocation in the market [19]. At the same time, relying solely on market instruments may be insufficient due to market failures and needs to be supplemented by government regulation. Policy integration theory emphasizes that various policy tools should be coordinated in design to form a synergistic effect rather than counteract each other[20].

In emission reduction practices, if one relies solely on market pricing, the carbon price signal might be insufficiently influenced by other factors to drive deep emission reductions; on the other hand, relying solely on administrative orders could be costly and inefficient. By integrating policies—combining economic instruments such as carbon trading with administrative measures like energy efficiency standards and renewable energy support—both the "invisible hand" that stimulates innovation and the "visible hand" that ensures the achievement of targets can be leveraged[21].

Multi-level governance theory, on the other hand, focuses on the interaction among different levels of government and multiple stakeholders, which in climate governance is reflected in a global–national–local multi-level synergy[22]. Carbon markets are often led by the national or transnational level (for example, the EU ETS is managed at the EU level), but their implementation requires cooperation from local enterprises[23]; correspondingly, local government's dual-control measures need to be aligned with national overall goals. This multi-level structure requires vertical coordination: the nation sets the rules of the carbon market and overall targets, while local governments implement them according to local conditions and can introduce innovative complementary measures—thereby forming a multi-faceted governance pattern under a unified objective[24]. For instance, the polycentric governance advocated by some scholars, which emphasizes autonomous yet coordinated climate actions at all levels, can enhance overall effectiveness. These theoretical perspectives converge on a consensus: the combination of market mechanisms and government intervention is an effective approach to achieving low-carbon transformation, with the key being the coordination of their roles and functional divisions[25].

2.3 Brief Comment

Overall, the existing literature shows that research on both carbon trading markets and dual-control policies for carbon emissions has achieved rich results. On the one hand, studies on carbon trading markets have fully affirmed the role of market mechanisms in reducing greenhouse gas emissions and have accumulated extensive experience regarding the design, operational performance, and impact assessment of carbon markets. Whether it is the emission reduction outcomes of mature markets such as the EU or the empirical validation of China's pilot projects, they all demonstrate that a well-designed carbon market can promote emission reduction while balancing economic efficiency. On the other hand, research on dual-control policies has deeply revealed the necessity and complexity of controlling energy and carbon emissions through administrative means. The implementation experience of China's dual control of energy consumption provides a reference for dual control of carbon emissions: the approach of assessing both intensity and total quantity has been effective in curbing the growth of high energy consumption, but it also reveals limitations such as an imperfect incentive structure.

Consequently, the emerging concept of carbon dual control has become a research hotspot, and the number of studies on policy design and effect simulation related to it has gradually increased. However, there are still some deficiencies and gaps in the existing research. Firstly, carbon markets and administrative control policies are often studied separately, lacking a systematic analysis of their interaction. Internationally, the synergistic effect of a "policy cocktail" has been discussed, but research on how carbon trading and dual-control policies coordinate in the Chinese context is still relatively limited. Secondly, although there are theoretical frameworks such as institutional economics and policy integration that can serve as references, their specific application to the analysis of the linkage between carbon markets and dual control is insufficient, lacking in-depth examination and quantitative evaluation of the synergistic mechanisms. Thirdly, from a practical perspective, the explorations in a few regions such as Shenzhen are worthy of attention, but existing literature has not adequately summarized and distilled these cases, and the generalizability and implications need to be further strengthened.

Based on the above literature context, this paper employs institutional economics, policy integration, and multi-level governance theories to conduct a cross-theoretical comprehensive analysis of the intrinsic mechanisms of synergistic governance between the carbon trading market and dual-control policies for carbon emissions. By comparing typical cases in Shenzhen and other regions both domestically and internationally, the aim is to propose policy recommendations to achieve a "dual-wheel drive" low-carbon governance model driven by both the government and the market.

3 CONSTRUCTION OF THEORETICAL FRAMEWORK

This study constructs an integrated "market–policy–level" tri-dimensional analytical model based on institutional economics, policy integration theory, and multi-level governance theory. The carbon trading market and dual-control policies for carbon emissions do not operate independently; rather, they complement and promote each other. Market mechanisms provide price signals and flexibility, while administrative measures ensure the stringency of emission reductions through target constraints, and the multi-level governance structure guarantees the coordination between national and local policies. Therefore, constructing a three-dimensional interactive analytical framework helps to comprehensively understand and optimize the carbon governance mechanism. This model elucidates the intrinsic logic of emission reduction governance from three dimensions:

1. Market Dimension (Institutional Economics)

Institutional economics emphasizes the supportive role of institutional arrangements in market operations. In the field of carbon reduction, carbon trading—as a concrete manifestation of market mechanisms—achieves the internalization of externalities and effective resource allocation through clear carbon emission quotas and trading rules. The effective operation of a carbon market relies on well-defined property rights, low transaction costs, and transparent market information[26].

2. Policy Dimension

Policy integration theory advocates for the coordinated combination of multiple policy tools to form a synergistic effect to achieve set goals. In carbon governance, dual-control policies for carbon emissions reflect the role of the government in planning and regulation. By combining administrative targets (such as total control and intensity assessment) with market mechanisms, the limitations of relying on a single instrument to achieve emission reduction targets can be overcome[27]. This dimension emphasizes that administrative measures not only provide necessary policy constraints for market mechanisms but also serve as an important guarantee for achieving policy objectives.

3. Hierarchical Dimension

Multi-level governance theory focuses on the coordinated interaction among various stakeholders and levels, such as the central government, local governments, and the market. Low-carbon governance not only requires the nation to formulate macro policies but also requires local governments to implement and innovate according to local conditions [22]. The overall strategy at the central level provides target orientation and resource support for local governance, while the experiences accumulated by local authorities in practical implementation can in turn inform higher-level decision-making, forming a virtuous cycle.

In summary, based on the above three theoretical perspectives, the "market–policy–level" model constructed in this study assumes that:

(1) Clear institutional arrangements provide the foundation for the efficient operation of market mechanisms;

(2) The integration of policy tools ensures an organic linkage between market operation and government emission reduction targets;

(3) The virtuous interaction between the central and local governments provides continuous impetus and assurance for the overall governance system.

In short, while market mechanisms provide efficiency, the government-set targets offer direction for emission reductions, and the multi-level governance structure ensures the organic integration of both in practical implementation.

4 THEORETICAL ANALYSIS OF THE SHENZHEN CASE

Using the comprehensive analytical model, this section explores the intrinsic synergistic mechanism between Shenzhen's carbon trading market and dual-control policies for carbon emissions. The aim is to reveal the interactive effects of market mechanisms and government intervention in low-carbon governance, and to provide theoretical support and practical insights for optimizing carbon reduction policy design.

4.1 Market-Policy Interaction Mechanism

When exploring how Shenzhen's carbon market can achieve synergistic effects with the dual-control policy for carbon emissions, it is necessary to consider both market mechanisms and administrative constraints. On one hand, carbon trading—as a market-oriented approach—establishes clear carbon emission quota systems and well-established trading rules, enabling enterprises to autonomously choose their emission reduction methods through market mechanisms[28]. At the same time, the dual-control policy for carbon emissions sets hard constraints on enterprises by establishing targets for total emission reduction and intensity. When the market carbon price falls below a predetermined threshold, the government can intervene promptly by adjusting the quota supply or establishing a green fund to stimulate enterprises' emission reduction efforts, thereby aligning market signals with policy objectives[29].

To further enhance overall policy implementation, optimization can be carried out from the following aspects:

- Firstly, establish a comprehensive carbon market price stabilization mechanism to ensure that when market signals are weak, dynamic adjustments in quota allocation can raise prices and thus stimulate proactive emission reductions by enterprises;
- Secondly, incorporate carbon market price signals into the carbon dual-control assessment system, thereby achieving a dual enhancement of policy flexibility and constraint effectiveness.

Through these measures, a virtuous interaction between market mechanisms and administrative intervention can be formed to jointly promote the achievement of low-carbon transformation goals.

4.2 Market-Policy Matching in Multi-Level Governance

Within the framework of multi-level governance, achieving low-carbon transformation relies not only on unified national policies but also requires local governments to engage in targeted innovation during implementation[30]. The central government is responsible for formulating the overall targets for carbon peaking and carbon neutrality, and for constructing a unified national carbon market framework to provide strategic guidance and basic standards for national low-carbon governance. Under this framework, local governments are tasked with implementing national macro policies on the ground and, based on their own economic structures, industrial distributions, and regional characteristics, optimizing and adjusting the operation mechanisms of the carbon market to better promote local low-carbon development.

As an important special economic zone in China, Shenzhen—while implementing national carbon market policies—actively explores innovative models tailored to regional realities. Specifically, Shenzhen can adopt a "regional carbon market integration" strategy to collaborate with other cities in the Guangdong-Hong Kong-Macao Greater Bay Area, thereby constructing a cross-regional carbon market network to enhance market liquidity and trading depth. Such regional cooperation not only helps to disperse the risks of a single city's carbon market but also integrates resources to form economies of scale, thereby elevating the overall level of low-carbon governance in the region.

Furthermore, Shenzhen can implement a "local pilot–national promotion" model. Under this model, Shenzhen can be the first to pilot stricter carbon market rules—for example, setting a higher carbon price floor and adopting more rigorous quota allocation methods—thereby establishing effective market constraints and incentive mechanisms at the local level. Subsequently, the experiences and results achieved during the pilot phase can be promoted nationwide, providing replicable and scalable policy models for other regions. Meanwhile, by using the revenues generated from the carbon market to support local low-carbon projects, an organic linkage between market mechanisms and local policy objectives can be further realized, forming a virtuous cycle of policy guidance, market operation, and local practice that mutually reinforce one another.

4.3 Optimization of Property Rights and Transaction Costs: The Effectiveness of Market Mechanisms

From the perspective of institutional economics, clearly defined property rights are the cornerstone for the efficient operation of the carbon trading market. As an independently traded asset, the operational effectiveness of Shenzhen's carbon emission rights largely depends on the clear delineation of emission reduction responsibilities for each enterprise [31]. Only under clear property rights can market participants engage in trading within a transparent and regulated institutional environment, effectively internalize externalities, and thereby achieve optimized resource allocation and effective cost reduction.

At the same time, reducing transaction costs is equally crucial for enhancing market activity and overall operational efficiency. To this end, Shenzhen can promote the "digitalization of the carbon market" reform by utilizing advanced technologies such as blockchain to improve information transparency and data sharing during transactions, thereby reducing trading frictions caused by information asymmetry. In addition, developing a diversified range of carbon financial products—such as carbon futures and carbon funds—can not only broaden market channels but also enhance market liquidity, further stimulating the enthusiasm of enterprises to participate in market transactions. Simultaneously, establishing an "enterprise carbon management platform" targeted at small and medium-sized enterprises to provide them with professional technical support can help lower the barriers to entry and transaction costs, thereby promoting the efficient operation of the entire market.

Based on the above analysis, the following optimization measures are recommended:

(1) Utilize digital means to comprehensively enhance market transparency and the level of information disclosure, thereby reducing trading risks;

(2) Further expand and improve the carbon financial product system to enhance market liquidity and the incentive effects for emission reduction.

Through these measures, Shenzhen's carbon trading market will achieve significant results in terms of clearly defined property rights and controlled transaction costs, thereby providing a solid market foundation for achieving low-carbon transformation goals.

5 CONCLUSIONS AND DISCUSSION

Shenzhen's linkage mechanism between its carbon trading market and its dual-control policy for carbon emissions constitutes a multi-dimensional, synergistic governance system. The core lies in the organic integration of the flexible regulation provided by market mechanisms with the administrative constraints imposed by the government—forming a linkage mechanism that both stimulates enterprises' autonomous emission reductions and ensures the achievement of overall emission reduction targets. From a theoretical perspective, this linkage mechanism is mainly reflected in three aspects:

1. Market and Policy Interaction Mechanism

By establishing clear carbon emission quota systems and well-established trading rules, Shenzhen enables enterprises to autonomously choose their emission reduction methods through market mechanisms. Simultaneously, the dual-control policy for carbon emissions sets hard constraints on enterprises by establishing targets for total emission reduction and intensity. When the market carbon price falls below a predetermined threshold, the government can intervene promptly by adjusting the quota supply or establishing a green fund to stimulate emission reduction efforts—thereby aligning market signals with policy objectives.

2. Hierarchical Governance Mechanism

Under the premise that the central government formulates unified overall targets for carbon peaking and carbon neutrality and establishes a national carbon market framework, local governments (such as Shenzhen) explore innovative models suited to regional characteristics based on their local industrial structures and practical conditions. Through the "regional carbon market integration" and "local pilot–national promotion" models, Shenzhen has not only established strict market rules and policy constraints at the local level but also promoted successful experiences nationwide, achieving efficient alignment between central policies and local practices.

3. Optimization Mechanism of Property Rights and Transaction Costs

Clearly defined property rights for carbon emission permits and reduced transaction costs are prerequisites for the efficient operation of the market. Shenzhen has improved trading transparency and market liquidity by promoting the digitalization of the carbon market, utilizing advanced information technology, and developing diversified carbon financial products. Moreover, by providing technical support to small and medium-sized enterprises to lower their barriers to entry, the overall efficiency of the carbon market has been further enhanced.

In summary, Shenzhen's linkage mechanism has constructed a multi-level, synergistic low-carbon governance system: market mechanisms provide a flexible and efficient trading platform, administrative policies ensure the achievement of established emission reduction targets, and effective coordination between central and local governance provides institutional assurance for this system. This model not only leverages the efficiency advantage of the market in resource allocation but also relies on strict policy constraints to achieve overall emission reduction targets—thereby providing solid support for low-carbon transformation and the realization of carbon peaking and carbon neutrality goals.

However, in practical operation, issues such as the refinement of the dynamic quota adjustment mechanism, the transmission effect of market price signals, and the sustainability of local policy innovation still have certain limitations and require further in-depth exploration. Future research should expand in the following aspects:

1. Quantitative Assessment and Empirical Analysis:

Combine quantitative methods to conduct in-depth empirical testing of the operational data of carbon markets in Shenzhen and other pilot cities to accurately evaluate the contribution of the market–policy linkage mechanism to carbon reduction outcomes.

2. Exploration of Regional Synergy Mechanisms:

Conduct in-depth analysis of the specific pathways and synergistic effects of integrating regional carbon markets within the Guangdong-Hong Kong-Macao Greater Bay Area, exploring feasible models for cross-regional low-carbon governance to provide a reference for constructing a unified national carbon market.

3. International Comparative Studies:

By comparing the operational experiences of mature markets such as the European Union and California, explore the applicability of different governance models in their respective economic and institutional environments, providing international insights for the reform of China's carbon market system.

4. Technological Innovation and Carbon Finance Development:

Focus on the application effects of digital technology and carbon financial products in enhancing market transparency and reducing transaction costs, and study the role of emerging technologies in optimizing the low-carbon governance system.

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THE SIGNIFICANCE OF EDUCATIONAL DEVELOPMENT IN A COUNTRY'S RESPONSE TO ECONOMIC CHALLENGE IN THE CONTEXT OF GLOBALIZATION

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Abstract: In the era of globalization, increased international cooperation and interaction have provided both opportunities and challenges for national development. Among these challenges, economic factors are particularly salient. Nations that effectively navigate these economic challenges can transform them into opportunities for growth and development. Conversely, failure to respond appropriately may result in lost opportunities and adverse effects on societal stability. Numerous scholars have posited that educational development is a fundamental prerequisite for countries to effectively address economic challenges in the context of globalization. This article seeks to analyze the critical importance of educational development in this framework.
Keywords: Globalization economic; Development knowledge; Economy

1 INTRODUCTION

Globalization represents a multifaceted phenomenon marked by the expansion of economic interconnections that cultivate new forms of decision-making, enhance cross-border communication, and establish novel regional and geopolitical orders [1]. This transformative process has imposed specific economic and political agendas upon societies worldwide, fundamentally altering the dynamics of international relations and domestic governance [2]. As noted by Burbules and Torres, globalization has blurred the lines of national boundaries, making it increasingly evident that events in one locale can be significantly influenced by developments occurring in multiple regions across the globe [3]. From an economic perspective, globalization can be comprehended as a large-scale transnational movement of capital, which facilitates the international circulation and turnover of resources [4]. This interconnectedness has prompted the world economy to undergo a fundamental transformation, characterized by the gradual supplanting of traditional industrial-based paradigms by a knowledge-based economy. This transition signifies a departure from industrial production, which historically relied heavily on inexpensive labor, toward an era where innovation, driven by advancements in technology and the Internet, plays a central role in economic success [5]. Consequently, the economic prosperity of nations increasingly hinges not merely on the skills of a select few but rather on the collective knowledge and competencies of their entire workforce. The creation, innovation, and application of knowledge have emerged as pivotal determinants of success for nations, industries, and individuals in the context of globalization [6].
In light of these changes, it becomes imperative to analyze the economic challenges induced by globalization, which can be delineated into several critical dimensions that reflect the complexities of the contemporary global economy.

2 ECONOMIC CHALLENGES INDUCED BY GLOBALIZATION

The economic challenges posed by globalization manifest in various forms, each demanding comprehensive analysis: (1) Resource Scarcity. One of the most pressing issues exacerbated by globalization is resource scarcity. In the 21st century, knowledge and technological resources have emerged as crucial determinants of a country's global standing. However, rapid population growth, coupled with unsustainable consumption patterns, has intensified strains on economic resources, transmitting the issue of scarcity to nations worldwide. The environmental degradation resulting from resource extraction and industrialization further complicates this scenario, as countries grapple with the dual challenges of economic development and ecological sustainability [7]. (2) Evolving Competitive Frameworks. The rules governing competition have undergone significant transformations in the wake of globalization (Brown & Lauder, 1996). Historically, domestic enterprises faced limited competition within local markets. However, globalization has intensified competition as foreign products and labor infiltrate domestic markets, thereby challenging local industries and undermining their competitive advantages. The influx of multinational corporations has not only increased competition but has also led to a race to the bottom regarding labor standards and environmental regulations in some regions. As nations strive to attract foreign investment, they may inadvertently compromise their own socio-economic standards, creating a precarious balance between economic growth and social equity. (3) Changing Labor Market Requirements. The labor market's demands have evolved dramatically in response to the shifting paradigms of globalization. Mechanization and automation have supplanted many operational tasks traditionally performed by skilled laborers, rendering certain job categories obsolete. Consequently, corporations increasingly seek innovative sources of productivity and investment to navigate global challenges. The prosperity of a nation's economy now relies on its capacity to identify and leverage the skills and knowledge of its workforce, rendering education indispensable [4].

The fundamental source of economic challenges stemming from globalization is the shift in the global economic structure from industrial to knowledge-based paradigms[8]. Knowledge has become the paramount factor of production, exerting a decisive influence on national economic development and global competitiveness. Nations, enterprises, and individuals that can access advanced knowledge and information will secure advantageous positions in the global marketplace. This transition from manual to intellectual labor necessitates enhanced educational opportunities for the populace. In my assessment, the economic challenges posed by globalization fundamentally revolve around competition for opportunities. Countries, enterprises, and individuals must bolster their competitiveness to thrive in this dynamic environment. In the knowledge economy, the pathway to improving competitiveness lies in education. Nations must undertake educational reforms to cultivate talents that meet the evolving demands of the labor market, thereby establishing a high-quality domestic labor pool and enhancing international economic competitiveness. The European Council's Lisbon Strategy underscored the necessity for member nations to aspire to become the world's most competitive and dynamic knowledge-based economies, ensuring sustainable growth and improved employment prospects for their citizens. In contemporary society, education is increasingly regarded as an economic investment aimed at cultivating a workforce capable of generating societal wealth [9]. The primary function of education is to prepare individuals for their future careers while simultaneously nurturing talent that contributes to societal progress and overall prosperity. In light of globalization, significant shifts in social structures necessitate the development and reform of education to align with the evolving needs of learners and society.

3 THE NECESSITY OF EDUCATIONAL DEVELOPMENT IN THE CONTEXT OF GLOBALIZATION

The World Bank asserted that educational development is central to addressing the economic challenges posed by globalization. Education serves as one of the most effective mechanisms for bridging the wealth gap within society, thus laying the groundwork for sustained and stable national economic growth. The contemporary global economy demands that workers possess adaptability, creativity, and critical thinking skills. Consequently, national strategies for workforce training must evolve in response to these new imperatives. Education must be reformed to enhance its efficiency, effectiveness, and economic relevance [3].

3.1 National Perspective

From the vantage point of national competitiveness, the increasingly globalized economy fundamentally represents a contest of comprehensive national strength. This strength is primarily reflected in a nation's levels of scientific, technological, and economic development. Economic advancement is predicated on scientific and technological progress, which, in turn, relies on a high-quality labor force. To thrive in the global economic landscape, virtually all countries recognize the development of education as a pivotal national strategy. In this context, the quality of a country's human resources is increasingly employed as a benchmark for assessing its economic development. In recent years, economists have introduced the concept of a "magnet economy". In the current era of globalization, workers possessing high-quality knowledge and skills command superior compensation. Developed nations typically exhibit a higher quality labor market, enabling workers to secure well-paying positions while attracting greater investment and resources, thereby fostering sustained economic growth. Conversely, low-skilled jobs are progressively relocated to developing countries.

While the "magnet economy" may mitigate resource scarcity issues in developed nations, it poses substantial challenges for developing countries. High-quality domestic talent is often lured to developed nations offering superior opportunities and remuneration, thereby constraining the ability of developing countries to compete effectively in the global economic arena. This dynamic leads to slower economic growth, limited job opportunities, and stagnant wages for workers, particularly in high-skilled sectors. This "magnet economy" framework disproportionately disadvantages developing countries. Nevertheless, both developed and developing nations must cultivate high-quality labor markets to mitigate the adverse consequences of this economic structure. Achieving a high-quality labor market necessitates educational reform and development, enabling students to acquire the knowledge and skills pertinent to the globalized economy. Only through such initiatives can countries secure a competitive advantage in international markets, attract valuable resources and investments, retain skilled jobs and talent, and foster technological advancement and stable economic growth.

As former President Barack Obama articulated in his commencement address at Hampton University, education serves to fortify the nation, bolster the economy, and equip citizens to navigate the challenges of the contemporary era. Education has become increasingly intertwined with economic development through various channels, playing a pivotal role in enhancing productivity and serving as a foundational pillar for economic progress [10]. A society devoid of educational resources lacks the necessary support for development; economic growth cannot be achieved without scientific and technological advancements, which are inextricably linked to education. Education cultivates high-quality talent essential for economic advancement, elevates societal standards, and facilitates the application of scientific knowledge through training, ultimately leading to increased productivity. In contemporary national development, the interplay between economy and education is symbiotic, necessitating effective cooperation to promote overall national growth.

Moreover, education is indispensable for enhancing national competitiveness in response to shifting competitive paradigms. Education and expanded training opportunities are vital for building a fair and competitive society while

simultaneously addressing rising domestic unemployment. They criticized the notion of "employment security", which historically aimed to protect uncompetitive enterprises, arguing that such an approach perpetuates inefficiencies. Ultimately, uncompetitive firms will be marginalized in the global marketplace, adversely impacting national competitiveness. The solution lies in investing in education and training, empowering workers to acquire the skills necessary to remain competitive, thereby enhancing the overall competitiveness of both enterprises and the nation.

3.2 Individual Perspective

Former President Barack Obama also emphasized the significance of education for individuals during his commencement address at Hampton University. He asserted that education equips individuals to withstand the economic uncertainties of the 21st century, serving as the primary means of preparation for global economic competition. In the context of rapid changes in the global economy, labor market requirements have evolved, necessitating workers to possess adaptable and transferable skills [11]. Workers with adaptability can seize developmental opportunities in new environments and endure economic fluctuations, whereas those lacking adaptability face marginalization in the labor market. The interconnectedness of global, national, and societal changes necessitates that work increasingly requires specialized knowledge, which is continuously evolving. To adapt to shifting labor market demands, the workforce must engage in ongoing learning across various fields. Consequently, continuous educational development is essential for imparting up-to-date knowledge and skills to individuals, enabling them to remain competitive in the global economy.

Analyzing the global labor market through the lens of the "magnet economy" concept reveals that high-quality jobs and resources are increasingly concentrated in developed nations, which also prioritize the importation of talented foreign labor. Developed economies are competing not only for high-quality jobs and resources but also for the most skilled workers. While the influx of exceptional foreign labor can yield economic benefits, it also poses challenges for the local workforce. As domestic labor markets become increasingly internationalized, children from affluent families may experience diminished advantages, while those from disadvantaged backgrounds confront heightened inequities. Disadvantaged children often lack access to quality educational resources, and the education system may not adequately equip them with the knowledge and skills required to compete effectively in the global job market. Thus, it is imperative for nations to prioritize educational development, equipping workers with the requisite knowledge and skills to thrive in the global economy. This emphasis is vital for enhancing individual competitiveness and securing advantageous positions in international markets. Furthermore, it is the only viable approach to assisting domestic workers in navigating the evolving challenges of talent requirements in the context of globalization.

4 CONCLUSION

The Organization for Economic Cooperation and Development underscored that both individuals and nations derive substantial benefits from educational development. For individuals, education facilitates access to rewarding and well-compensated employment, contributing to overall life satisfaction. For nations, education enhances the quality of the labor market, ensuring sustained economic growth while promoting social cohesion and stability. Consequently, in light of globalization, national development and educational reform must be prioritized [4]. Moreover, globalization necessitates the establishment of a lifelong learning framework that provides citizens with continuous educational opportunities. The sustainable development of the national economy must rest on a foundation of sustainable educational practices, offering individuals an education system that fosters continuous learning and development. Individuals, in turn, must cultivate a commitment to lifelong learning to ensure they maintain relevance and value in an ever-evolving world.

In conclusion, the interplay between globalization and education is crucial for navigating the complexities of the modern economy. Nations that prioritize educational development will not only enhance their competitiveness on a global scale but will also ensure that their citizens possess the necessary skills and knowledge to thrive in an increasingly interconnected world. This strategic focus on education will serve as a catalyst for economic growth, social progress, and the realization of a more equitable global society.

COMPETING INTERESTS

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STRATEGIES FOR HIGH-QUALITY DEVELOPMENT OF LOCAL VOCATIONAL COLLEGES UNDER "CHINA'S DOUBLE HIGH-LEVEL PLAN"

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Abstract: The Double High-Level Plan (DHP), a national strategy to enhance vocational education quality in China, faces persistent challenges in addressing regional disparities, particularly in underdeveloped provinces such as Yunnan. This study evaluates operational efficiency gaps between nationally designated DHP institutions and vocational colleges in Yunnan, aiming to propose actionable strategies for optimization. A dual-model Data Envelopment Analysis framework was applied to assess inputs, including financial allocation and human resources, alongside outputs such as facility utilization, talent cultivation, social services, and internationalization. Results reveal that Yunnan colleges demonstrate higher scale efficiency due to resource-constrained adaptation but exhibit significant deficits in technical efficiency, faculty qualifications, and international engagement compared to DHP institutions. Key challenges stem from fiscal limitations, industrial mismatch, and geographic marginalization. To address these issues, the study advocates cross-regional industry-education collaborations, curriculum digitalization, and incentive-driven faculty development initiatives. These findings contribute empirical insights for optimizing resource allocation and advancing equitable vocational education under the DHP framework, offering a reference for similar regional contexts globally.
Keywords: DHP; DEA; Vocational education efficiency; Regional disparities; Resource optimization

1 INTRODUCTION

The DHP, officially known as the "Construction Plan for High-Level Vocational Schools and Majors with Chinese Characteristics," represents a pivotal national strategy to elevate the quality of vocational education in China. Since its inception, the DHP has aimed to foster institutional competitiveness, optimize resource allocation, and cultivate high-skilled talent aligned with industrial demands. While existing studies have extensively evaluated the implementation efficacy of the DHP, challenges persist in addressing regional disparities in educational efficiency, particularly in underdeveloped provinces such as Yunnan. These disparities manifest in imbalanced resource inputs, suboptimal faculty structures, and lagging student outcomes, thereby undermining the equitable development of vocational education.

Prior research has predominantly focused on assessing the operational efficiency of DHP-designated institutions using methodologies like Data Envelopment Analysis and Tobit regression. However, few studies have conducted comparative analyses between nationally recognized "Double High-Level" institutions and regional vocational colleges, especially those in geographically and economically disadvantaged areas. This oversight limits the understanding of how structural constraints—such as fiscal inadequacy, industrial underdevelopment, and talent drain—shape the efficiency landscape of vocational education in regions like Yunnan.

To address this gap, this study employs a dual-model DEA framework (CCR and BCC) to evaluate the operational efficiency of 56 DHP institutions and 31 vocational colleges in Yunnan Province. By constructing a multi-dimensional indicator system encompassing financial inputs, human resources, facility utilization, and educational outputs, the research quantifies efficiency gaps across regions and identifies key bottlenecks. The findings reveal that while Yunnan's institutions exhibit relatively high scale efficiency due to forced adaptation to resource scarcity, they suffer from significant deficits in technical efficiency, faculty quality, and international engagement compared to their DHP counterparts.

This study contributes to the literature in three ways. First, it provides empirical evidence on the heterogeneous efficiency patterns between national and regional vocational institutions, highlighting the compounding effects of geographic marginalization and economic underdevelopment. Second, it proposes actionable strategies for optimizing resource allocation, enhancing faculty capacity, and leveraging regional advantages to foster sustainable development. Finally, the research offers policy insights for bridging regional educational divides and advancing the DHP's goals of equitable, high-quality vocational education.

By integrating quantitative analysis with contextualized policy recommendations, this work underscores the urgency of adopting a multi-dimensional innovation system to transform Yunnan's vocational education from a resource-dependent model to one driven by strategic collaboration, digital transformation, and institutional resilience. The implications extend beyond regional contexts, offering a reference for addressing efficiency disparities in vocational education systems globally.

2 LITERATURE REVIEW

Research on the DHP primarily focuses on evaluating its implementation effectiveness, identifying challenges, exploring future directions, and proposing optimization strategies.

Li Xianzheng conducted a literature review to examine the status and implications of developmental evaluation by integrating historical practices of vocational college assessments in China [1]. Tang Ni analyzed the operational efficiency and influencing factors of DHP institutions, proposing strategies to optimize resource allocation [2]. Lee, Boon L., and Johnes, Jill applied a network DEA model to evaluate teaching quality in UK higher education and offered policy recommendations [3]. Mao Jianqing et al. investigated how university funding structures affect academic output and identified theoretical optimal values to enhance productivity [4]. Zhou Fei explored the mechanisms through which vocational students' learning engagement influences their institutional identity, providing actionable recommendations to strengthen this connection [5]. Hu Dexin et al. employed social structuration theory to study development pathways, challenges, and improvement strategies for vocational colleges [6]. Zhou Jiansong et al. discussed approaches to elevate talent cultivation quality through high-level specialized program clusters, driving high-quality vocational education [7]. Yang Wenjie et al. examined the value orientation, practical dilemmas, and solutions for western China's vocational education under the DHP framework [8]. Du Yamin and Seo Wonchul analyzed input-output efficiency and management of R&D activities across Chinese universities, proposing enhancement measures [9]. Xue Wuzhao et al. evaluated static and dynamic efficiency of research activities at universities directly under China's Ministry of Education, suggesting optimization strategies [10]. Jiang Jiali et al. assessed research efficiency in Chinese universities and provided improvement recommendations [11].Existing studies share common objectives: evaluating educational quality and efficiency improvements, identifying implementation challenges, optimizing resource allocation and performance management systems to boost institutional efficiency and academic output, and exploring pedagogical and curricular innovations to enhance talent cultivation quality.

Scholars adopted diverse research methods. Li Xianzheng combined literature analysis with historical evaluation practices and value orientations in vocational education [1]. Tang Ni utilized Data Envelopment Analysis (DEA) and Tobit regression to quantify operational efficiency across 56 DHP institutions [2]. Lee and Johnes integrated network DEA with qualitative and quantitative data (e.g., UK Teaching Excellence Framework) [3]. Mao Jianqing et al. employed a two-way fixed-effects model to analyze funding-academic output relationships [4]. Liu Bin et al. applied the Delphi method to establish weights for a three-tier indicator system, enabling measurable comparisons [12]. Sun Hui et al. developed an evaluation index system aligned with China’s Vocational Education Quality Enhancement Action Plan to propose development pathways [13]. Ma Xinyue et al. used DEA to assess DHP institutions' operational efficiency. Yuan Ke et al. applied a progressive Difference-in-Differences (DID) method, using QS rankings and student satisfaction metrics to evaluate the impact of targeted funding [14]. Yang Yanyan et al. constructed a Balanced Scorecard-based index system spanning teaching, research, finance, and social performance [15]. Xie Qian et al. employed CiteSpace and SATI for bibliometric visualization, analyzing keyword and burst term patterns [16]. Du and Seo combined DEA–Malmquist models with scientific-statistical data to assess regional R&D efficiency [9]. Xue Wuzhao et al. applied three-stage DEA and Malmquist indices to evaluate research efficiency at ministry-affiliated universities [10]. Jiang Jiali et al. leveraged DEA to measure research efficiency nationwide [11]..Key methodologies include DEA for institutional/research efficiency evaluation, Tobit regression for factor quantification, and hybrid network DEA models integrating qualitative-quantitative data. These approaches enable comparative analyses, enhance scientific rigor, and provide robust evidence for policy formulation and technical guidance.

3 RESEARCH METHOD AND INDICATOR CONSTRUCTION

3.1 Research Method

The operational performance evaluation of higher vocational colleges is a complex process involving multi-dimensional inputs and outputs. Due to the numerous indicators and intricate interrelationships, conventional simplistic evaluation systems prove inadequate. Data Envelopment Analysis (DEA), a non-parametric analytical method utilizing linear programming, enables efficiency measurement in multi-input and multi-output models by incorporating multiple indicators, making it particularly suitable for this research. This study employs DEA models to evaluate the operational efficiency of 56 "Double High-Level" institutions and 31 higher vocational colleges in Yunnan Province. Specifically, the CCR model is adopted to assess overall efficiency, while the BCC model is further applied to examine efficiency differences under variable returns to scale. The CCR model assumes constant returns to scale for all decision-making units (DMUs), whereas the BCC model accounts for variable returns to scale, offering a refined efficiency evaluation framework.

By integrating both CCR and BCC models, this research aims to quantify operational efficiency disparities between nationally recognized "Double High-Level" institutions and regional vocational colleges in Yunnan Province. The CCR model facilitates preliminary identification of overall efficiency, while the BCC model reveals efficiency performance under varying scale conditions. This dual-model approach not only distinguishes effective from ineffective DMUs but also provides comprehensive efficiency assessment outcomes. The findings will inform educational policymaking, optimize resource allocation, enhance rational distribution of educational resources, and improve teaching quality. Furthermore, this study delivers scientific evidence and actionable recommendations for advancing vocational education development in Yunnan Province.

3.2 Indicator Construction

Based on the performance indicator construction method for DEA analysis proposed by Ma Xinyue et al.[14], and aligned with the core operational indicators of higher vocational colleges in Yunnan Province, this study establishes a comprehensive evaluation system encompassing input and output dimensions. Input indicators include annual per-student financial allocation under the financial investment dimension and the number of full-time teachers representing human resource investment. Output indicators are structured into five aspects: school facilities and equipment, measured by per-student value of teaching and research instruments and per-student land area to assess resource conversion efficiency and spatial allocation; faculty team development, reflected in the proportion of teachers with master's degrees or higher and dual-qualified teachers to evaluate academic structure optimization and industry-education integration; talent cultivation outcomes, integrating enrolled student scale, graduate employment rate, and student competition awards to systematically gauge talent development capacity, social adaptability, and innovation; social service contributions, represented by non-degree training participation to quantify vocational skill enhancement efforts; and international cooperation impact, measured by the scale of international students to reflect global educational influence. The system positions "facilities-faculty-talent cultivation" as the core competency layer, extending to "social services-international cooperation" as the external benefit layer, forming an integrated evaluation framework that deepens insights into vocational education's foundational role while highlighting its contributions to industrial advancement and global engagement(Table 1).

Table 1 Indicator Classification

Primary Indicator	Secondary Indicator	Unit	Label
Input of Financial Allocation	Average Annual Financial Allocation per Student	Yuan/person	X1
Input of Human Resource	Number of Full-time Teachers in School	Person	X2
Output of School Facilities and Equipment	Average Value of Teaching and Research Instruments per Student	Yuan/person	Y1
	Average Land Area per Student	m^2/person	Y2
Output of Faculty Team	Proportion of Teachers with Master's Degree or Above	%	Y3
	Proportion of Dual-qualified Teachers	%	Y4
Output of Talent Cultivation	Equivalent Scale of Enrolled Students	%	Y5
	Graduate Employment Rate	%	Y6
	Number of Student Competition Awards	Count	Y7
Output of Social Services	Non-degree Training Participants	Person/day	Y8
Output of International Cooperation	Scale of International Students	Person	Y9

4 DATA ANALYSIS

4.1 Comparative Analysis

Notably, multidimensional gaps exist between higher vocational colleges in Yunnan Province and DHP Vocational Colleges, with pronounced disparities in resource investment, faculty structure, and student cultivation outcomes. To systematically evaluate these gaps, the dataset was divided into two groups: DHP institutions and Yunnan-based colleges. Averages were calculated for each group, and a comparative analysis was conducted to quantify differences across key indicators, as illustrated in Figure 1 below.

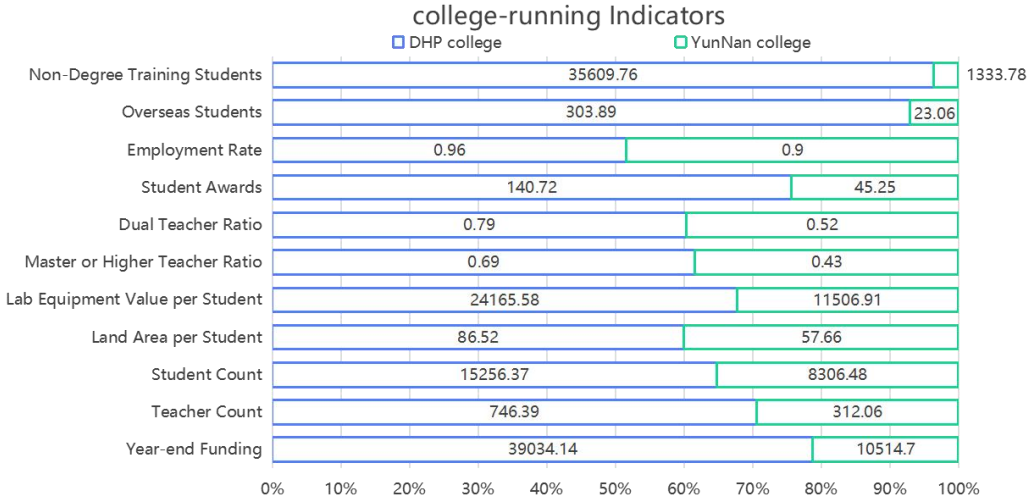

Figure 1 Comparative Analysis

In terms of resource investment, higher vocational colleges in Yunnan Province exhibited an annual financial allocation of 105.147 million yuan, equivalent to only 26.9% of the 390.3414 million yuan allocated to DHP institutions. This

insufficient fiscal support directly constrained infrastructure development: the per-student land area in Yunnan colleges was 57.66 m², 33.4% lower than the 86.52 m² in DHP institutions, while the per-student laboratory equipment value of 11,506.91 yuan represented less than half of the 24,165.58 yuan in DHP colleges.

Faculty-student ratio imbalances further exacerbated resource constraints. Yunnan colleges had 312.06 full-time teachers and 8,306.48 enrolled students, accounting for only 41.8% and 54.5% of the corresponding figures in DHP institutions, respectively. This imbalance, coupled with diluted per-student resources, significantly limited teaching and research capacity.

Regarding faculty structure, Yunnan colleges reported a 43% proportion of teachers with master's degrees or higher, significantly lower than the 69% in DHP institutions. The proportion of dual-qualified teachers in Yunnan (52%) also lagged by 27 percentage points compared to 79% in DHP colleges. These gaps reflect insufficient high-level talent reserves and weak industry-academia collaboration mechanisms, undermining pedagogical innovation and industry service capabilities.

In student cultivation outcomes, Yunnan colleges recorded 45.25 student competition awards, less than one-third of the 140.72 awards achieved by DHP institutions. The international student enrollment of 23.06 students in Yunnan represented a mere 7.6% of the 303.89 students in DHP colleges, while non-degree training participation (1,333.78 participants) was only 4% of the 35,609.76 participants in DHP institutions. These metrics highlight systemic challenges, including weak academic competitiveness, delayed internationalization, and ineffective social service functions. The graduate employment rate in Yunnan (90%) showed a relatively smaller gap compared to the 96% rate in DHP colleges.

4.2 DEA Analysis

Generally, categorize Data Envelopment Analysis (DEA) efficiency scores as follows: ≥0.8 indicates high efficiency, 0.5–0.8 denotes moderate efficiency, and <0.5 reflects low efficiency [14]. Using DEA-SOLVER Pro5.0, input-output indicators were processed to calculate comprehensive efficiency (technical efficiency), pure technical efficiency, scale efficiency, and returns to scale for institutions across five regions: Eastern, Western, Central, Northeast, and Yunnan. Results are summarized in Table 2.

Table 2 DEA Results

Region	Sample Total	Average TE	TE=1 Count	Average PTE	PTE=1 Count	Average SE	SE=1 Count
Eastern	46	0.66	17	0.99	28	0.67	11
Western	25	0.59	10	0.98	14	0.6	5
Central	11	0.71	5	0.98	7	0.72	4
Northeast	3	0.67	0	0.97	2	0.69	0
Yun Nan	21	0.79	10	0.96	13	0.82	10

Data analysis reveals that most institutions achieved a pure technical efficiency of 1, indicating that input-output effectiveness is well ensured under current management systems and practices. However, significant anomalies were observed in scale efficiency. Among all 85 higher vocational colleges, only 17 achieved scale efficiency of 1, while the majority, 81.2 %, operated below 0.9. This suggests that over 80 % of institutions suffer from excessive operational scale and need to downsize to improve efficiency.

In Yunnan, only 47.6 % of institutions achieved pure technical efficiency of 1, significantly lower than regions such as Eastern, Western, Central, and Northeast, where the rates exceeded 65 %, with Central reaching 71.4 %. This highlights Yunnan's shortcomings in management capabilities. Conversely, Yunnan exhibited the best performance in scale efficiency. Eleven out of 31 institutions achieved scale efficiency of 1, accounting for 35.5 %, far surpassing Central at 28.6 %, Eastern at 9.7 %, Western at 7.7 %, and Northeast with none. This contradiction underscores that while Yunnan institutions have relatively rational scale configurations, their management practices still lag behind national benchmarks, necessitating institutional optimization to bridge the efficiency gap.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The scale efficiency advantage observed in Yunnan's higher vocational colleges under DEA analysis is fundamentally a passive adaptation to the combined effects of its western geographic location and lagging economic development. As a southwestern border province, Yunnan faces structural challenges due to complex terrain, sparse transportation networks, chronic fiscal underinvestment, and weak capacity for educational resource aggregation. The regional economy, dominated by low-value-added traditional industries such as agriculture and tourism, with slow technological upgrading, constrains the demand hierarchy for vocational education. Institutions are compelled to prioritize low-skilled training programs, struggling to establish high-quality talent cultivation systems aligned with emerging industries. This dual collapse in economic foundation and educational investment results in Yunnan's annual funding amounting to less

than one-third of DHP institutions, while per-student laboratory equipment value is only half of the national benchmark. Severe hardware shortages force institutions to downsize operations to sustain basic efficiency.

Furthermore, the closed educational ecosystem in western China exacerbates competency gaps. Remote geographic positioning reduces talent attraction, with the proportion of teachers holding master's degrees or higher lagging 26 percentage points behind DHP institutions, and a 27% deficit in dual-qualified teachers. This faculty structure fracture perpetuates weakened pedagogical innovation and industry service capabilities. Concurrently, low technological sophistication in regional industries leads to superficial industry-education collaboration, limiting 校企 partnerships to basic internship arrangements rather than deep technical integration or customized training. The interplay of geographic marginality, low-end economic structure, and constrained educational investment creates a distorted pattern of "passively optimized scale but dysfunctional technical efficacy."

The efficiency dilemma of Yunnan institutions is further entrenched by regional development disparities and institutional stagnation. DHP institutions in eastern China leverage industrial agglomeration and policy-driven resource advantages to establish dynamic "disciplinary cluster-industry chain" coupling mechanisms. Their digital governance models and dense industry-academia networks efficiently convert abundant resources into technical skill outputs. In contrast, Yunnan institutions, constrained by homogeneous local industries and weak institutional innovation, remain trapped in a low-end equilibrium under comparable management frameworks. Outdated administrative practices result in underutilized laboratory equipment, curricula outdated against industry demands, and non-degree training participation at merely 4% of DHP levels, exposing atrophy in social service functions. This systemic inertia underscores the urgent need for policy interventions to recalibrate resource allocation, modernize governance, and foster adaptive industry-education ecosystems.

5.2 Recommendations

To advance the reform and development of higher vocational education in Yunnan, a multidimensional innovation system must be established, prioritizing the creation of an "Eastern-Western Collaboration + Local Characteristics" industry-education integration ecosystem. This involves constructing cross-regional industry-education alliances through national East-West cooperation mechanisms, implementing an innovative "1+1+N" collaborative model to align high-quality educational resources from Eastern DHP institutions with Yunnan's specialized disciplines. Virtual teaching and research platforms should be developed in fields such as green energy and cross-border e-commerce to enable interregional sharing of curricula and practical training resources, while synchronizing technical standards with talent cultivation mechanisms. Leveraging Yunnan's ecological assets and border location, provincial special funds should be allocated to cultivate distinctive discipline clusters in digitalized plateau agriculture and cross-border tourism services. Collaborative projects with enterprises along the China-Laos Railway and cross-border cooperation zones should develop "language + skills + commerce" interdisciplinary talent programs, forming an educational supply system aligned with Regional Comprehensive Economic Partnership (RCEP) industrial chains.

A "dual-track strategy of attraction and cultivation" is essential for faculty development. Competitive recruitment mechanisms for high-level talents should include relocation subsidies, research funding, and industry project linkages. To address structural shortages of dual-qualified teachers, an "engineer-in-residence" program should integrate corporate technical experts into campuses, with enterprise participation incorporated into social responsibility evaluations. A provincial dual-qualified teacher certification center, jointly developed with leading tech firms, should establish digital teaching competency standards and industry practice renewal mechanisms, directly linking certifications to promotions and performance-based salaries to foster continuous professional growth.

A "hardware-software synergy" model must be implemented. Provincial digital education funds should prioritize virtual simulation training systems and a unified "cloud vocational education" platform to enable cross-institutional resource sharing and equipment optimization. Flexible credit systems, including a "credit bank" and lifelong learning mechanisms, should allow skill certifications to convert into academic credits. Seasonal "peak practice + off-peak theory" schedules could expand non-degree training participation to over 20% of DHP levels within three years. Concurrently, smart training base efficiency evaluations should ensure equipment utilization rates exceed 85%.

A dynamic "incentive-constraint balance" framework is critical. Funding growth mechanisms should link vocational education investments to fiscal revenues, ensuring annual per-student allocations increase by ≥8%, supplemented by provincial vocational education bonds for border infrastructure. Enterprises engaged in industry-education integration should receive education surtax reductions and preferential land-use quotas to incentivize participation. Third-party monitoring systems must evaluate institutional performance using metrics such as international student enrollment and technology transfer income, issuing warnings and corrective mandates to underperforming institutions to enforce accountability.

COMPETING INTERESTS

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THE IMPACT OF ENVIRONMENTAL REGULATION ON THE CARBON EMISSION EFFICIENCY OF THE LOGISTICS INDUSTRY IN YRD

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Abstract: Against the backdrop of global climate change, the carbon emissions of the logistics industry are becoming increasingly prominent. The research focuses on the impact of environmental regulation on the carbon emission efficiency of the logistics industry, based on the panel data of the Yangtze River Delta region from 2011-2021, the super efficiency SBM model is used to measure the carbon emission efficiency, and the mechanism of the command and market incentive environmental regulation tools is empirically analyzed with the random effect model. It has found that both environmental regulatory tools have a significant positive impact on the carbon emission efficiency of the logistics industry; the improvement of technological innovation level, foreign investment level, and financial development level also helps to enhance the carbon emission efficiency. This study enriches the research perspective on the relationship between environmental regulation and industry carbon emission efficiency, providing a theoretical basis for the agency to formulate scientific and reasonable environmental regulation policies.
Keywords: Environmental regulation; Logistics industry; Carbon emission efficiency; Super efficient SBM model; Random effect model

1 INTRODUCTION

Global climate change has become one of the most pressing challenges facing humanity in the 21 century [1]. With the signing of the Paris Agreement, agencys are working to reduce greenhouse gas emissions in order to limit the rise in global average temperature [2]. The logistics industry, as an important support for economic and social development, has been developing rapidly in recent years and at the same time has brought about a large amount of carbon emissions, putting pressure on the regional ecological environment [3]. According to the International Energy Agency (IEA), the transportation sector accounts for nearly a quarter of the world's total carbon emissions, and logistics activities, as an important part of the sector, have a huge potential for reducing emissions. How to realize carbon emission reduction while promoting the development of the logistics industry has become an urgent issue.

Environmental regulation, as an important means for the agency to regulate economic development and environmental protection, has received widespread attention due to its impact on carbon emission efficiency, research results are not consistent. One view is that environmental regulations increase compliance costs for businesses, and driven by the goal of maximizing profits, businesses may be unwilling to invest in technological innovation, resulting in higher pollutant emissions [4,5]. More scholars believe that reasonable environmental regulations can force high energy consuming and high polluting enterprises to innovate production technology and upgrade pollution control technology, thereby reducing pollutant emissions [6-8]. The effects and mechanisms of heterogeneous environmental regulatory tools on carbon emissions are different [9], and there is spatial heterogeneity in the carbon reduction effects of different regions and manufacturing industries [10,11]. Scholars have proposed an inverted U-shaped relationship between environmental regulation and carbon emission [12], where a green paradox effect exists when environmental regulation is at a low level, and innovative emission reduction effects begin to emerge after reaching a threshold [13].

A review of the existing literature reveals that most research perspectives focus on the macro-regional level or traditional energy-consuming industries such as industry and manufacturing, and pay insufficient attention to the logistics industry, which is a modern service industry that is both basic and high-growth in nature [14]. Taking the Yangtze River Delta (YRD) region as a research unit, this study constructs a super-efficient SBM model with undesired outputs to systematically measure the carbon emission efficiency of the logistics industry from 2011 to 2021, and empirically examines the paths of the two types of environmental regulatory tools based on the random-effects model. On the theoretical level, this study expands the application scenarios of environmental regulation theory in the service industry by revealing the industry-specificity of the carbon emission efficiency of the logistics industry and the law of regulatory tool adaptation; on the methodological level, the combination of the super-efficient SBM model with the panel data model provides methodological innovation for the multi-dimensional evaluation of environmental policy effects. The study can, on the one hand, provide a decision-making basis for the agency to formulate a more scientific and reasonable environmental regulation policy, and promote the coordinated development of the logistics industry and environmental protection; on the other hand, it can help to guide the logistics enterprises to strengthen the technological innovation and management innovation, to improve the efficiency of carbon emission, to reduce the operation cost and to enhance the market competitiveness.

2 METHOD

2.1 Modeling

In this paper, the random effects model is used to investigate the impact of two environmental regulation tools on the carbon emission efficiency of the logistics industry. Random effects model (REM) treats the regression coefficients in the original fixed effects model as random variables, which is mainly used for modeling and analyzing panel data and longitudinal data, and it is an effective tool for solving the correlation problem of statistical data due to clustering. Compared with the fixed-effects model, the random-effects model requires fewer model coefficients to be estimated and has a higher degree of freedom in the model [15]. This means that in the case of limited data sample size, the random effects model can better utilize the data and improve the model fitting effect and prediction accuracy. The specific formula is as follows:

$$Y_{it} = \alpha_i + X_{it}^{\mathrm{T}}\beta_{it} + u_i + \omega_{it}\# \tag{1}$$

Where $i = 1,2,\cdots,N$ is different individuals in the panel data;$t = 1,2,\cdots,T$ is different time in the panel data. $Y_{it}$is the explained variable, here is the carbon emission efficiency of the logistics industry;X_{it} is the explanatory variable, $X_{it} = \left(X_{1,it}, X_{2,it}, \cdots, X_{k,it}\right)^{\mathrm{T}}$, including the two environmental regulation tools of command and market incentive ;α_i denotes the unknown parameter ;u_i is the random error term of the$i$ th individual.

2.3 Explained Variables

Carbon emission efficiency refers to the maximum economic growth and minimum CO_2 emissions that can be obtained with no increase in capital, labor and energy inputs, which means more economic output and better quality of life with less carbon emissions. In our research, the carbon emission efficiency of the logistics industry is modeled by the super-efficient SBM model that takes into account the undesired output [16]. The specific calculation formula is as follows.

$$\begin{gathered} min\rho^* = \frac{1+\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{X_{ik}}}{1-\left[\frac{1}{s_1+s_2}\left(\sum_{r=1}^{s_1}\frac{s_r^g}{y_{rk}^g}+\sum_{t=1}^{s_2}\frac{s_r^b}{y_{tk}^b}\right)\right]} \\ s.t.\, x_{ik} \geq \sum_{j=1,j\neq k}^{n} x_{ij}\,\lambda_j - s_i^- \\ y_{ik} \geq \sum_{j=1.j\neq k}^{n} y_{tj}^b\,\lambda_j - s_t^b \\ 1-\frac{1}{s_1+s_2}\left(\sum_{r=1}^{s_1}\frac{s_r^g}{y_{rk}^g}+\sum_{t=1}^{s_2}\frac{s_r^b}{y_{tk}^b}\right) > 0 \\ s^-、\ s^g、\ s^b、\ \lambda \geq 0 \end{gathered} \tag{2}$$

Where n denotes the decision unit;s_1 denotes the desired output element;m denotes the production input element;s_2 means the undesired output element;s^g is the undesired output element;s^- is the undesired output element;s^b denotes the undesired output element;λ is the vector of weights;k is the unit being evaluated; and ρ^* is the efficiency value of the decision unit.

The study takes capital, labor and energy inputs as the input indicators for measuring the carbon emission efficiency of the logistics industry. The capital input indicator is the capital stock of the logistics industry in each province and city, which will be calculated by using the perpetual inventory method (PIM) at constant price. The labor input indicator is expressed by the number of employees in the logistics industry in each province. The energy input indicator is expressed by the energy consumption of logistics industry in each province (municipality directly under the central agency) .

The output indicator is divided into two indicators: desired output and non-desired output. The desired output indicator is chosen to be represented by the value added of the logistics industry . The non-desired output will be characterized by the carbon emissions of the logistics industry [17]. The calculation of carbon emissions is based on the formula provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories prepared by the Interagencyal Panel on Climate Change [18] . The formula is shown below.

$$CO_2 = \sum CO_{2,i} = \sum E_i \times NCV_i \times CEF_i \times COF_i \times \frac{44}{12} \tag{3}$$

Where,i indicates the type of final energy consumption, this research selects kerosene, natural gas, raw coal, diesel, fuel oil, gasoline and electricity as the main sources of energy consumption in the logistics industry, and the detailed data are shown in Table 2. NCV indicates the low-level heat production;CEF is the carbon content;COF is the carbon oxidation rate ;44 and 12 indicate the molecular weight of carbon dioxide and carbon, respectively; and$NCV_i \times CEF_i \times COF_i \times \frac{44}{12}$ means the way of calculating the carbon emission coefficients of the respective fossil fuels.

Table 2 Detailed Data Sheet for Energy Measurement

Energy source	Average low calorific value (kJ/kg)	Carbon content per unit calorific value (kJ/kg)	Carbon oxidation rate	Conversion standard coal factor (Kgce/Kg)	Carbon emission factor (kg-CO2/kg)

raw coal	20908	26.37	0.94	0.7143	1.9003
crude oil	41816	20.1	0.98	1.4286	3.0202
diesel	43070	18.9	0.98	1.4714	2.9251
gasoline	43070	19.5	0.98	1.4714	3.0179
diesel fuel	42652	20.2	0.98	1.4571	3.0959
fuel oil	41816	21.1	0.98	1.4286	3.1705
liquefied petroleum gas	50179	17.2	0.98	1.7143	3.1013
petroleum	38931kJ/m3	15.3	0.99	1.215 Kgce/m3	2.1622 kg-CO2/m3
electrical power	-	-	-	0.404Kgce/Kw.h	-

2.3 Explanatory Variables

Scholars have categorized environmental regulatory tools into three main types, namely, command, market incentive and voluntary [19]. Generally speaking, the command environmental regulatory tools is the agency to use coercive means to order enterprises to implement the environmental standards set by the agency to reduce the enterprise pollution of the environment, this kind of regulatory tools are effective, but the implementation cost is higher. Market incentive environmental regulation tools can effectively reduce the mandatory orders, reduce the cost of agency intervention, to a certain extent, can improve the efficiency of environmental governance. Voluntary environmental regulation tools generally refer to the voluntary behavior of enterprises to actively reduce the environmental impact of enterprises. Considering the practical limitations and data deficiencies of voluntary environmental regulation tools in the logistics industry, two environmental regulation tools are selected, namely, command and market incentive, to study their impact on the carbon emission efficiency of logistics enterprises. The strength of the command environmental regulation tool is characterized by summing up the freight cost of treating wastewater and waste gas facilities with the value added of industry, and the market incentive environmental regulation testing tool is expressed by the ratio of the completed investment in industrial pollution control to GDP [20].

2.4 Control Variables

2.4.1 Technology level of innovation

The technological innovation of logistics enterprises is conducive to the realization of cost reduction and efficiency, reduction of carbon dioxide emissions and reduction of environmental pollution [21]. Used entropy value method to comprehensively evaluate the four indicators of R&D personnel, R&D expenditure, the number of invention patent authorization and technology market turnover in each region, and reflected the level of technological innovation in each region by the method of comprehensive evaluation.

2.4.2 Level of human capital

Human capital is one of the key factors driving economic growth. A high level of human capital helps to enhance the country's industrial competitiveness and promote technological innovation and industrial upgrading, thereby promoting sustained economic growth [22]. The human capital indicator is expressed as the ratio of students enrolled in higher education to the total population of the region.

2.4.3 Level of foreign investment

Foreign investment usually brings in large amounts of capital, which helps to increase domestic investment and promote capital formation, thereby boosting economic growth [23]. These funds can be used for infrastructure construction, technological research and development, industrial upgrading, and many other aspects, providing impetus for economic development. The indicator is expressed in terms of the share of foreign direct investment in GDP.

2.4.4 Level of agency intervention

The level of agency intervention may directly affect the enthusiasm of logistics enterprises to actively reduce carbon emissions, and the indicator is expressed as the proportion of local agency general public budget expenditure to GDP [24].

2.4.5 Level of financial development

The level of financial development can be measured in a number of dimensions, including the number and size of financial institutions, the size of the capital market, financial depth, financial breadth, financial efficiency and financial stability. In the text, the deposit and loan balances of financial institutions in each province as a percentage of GDP are used to express this.

3 CASE STUDY

3.1 Background

The Yangtze River Delta(YRD) region is one of the most economically dynamic and innovative city clusters in China, covering 41 cities in Shanghai, Jiangsu, Zhejiang and Anhui Provinces, with a total area of about 358,000 square kilometers. As the intersection hub of the "Belt and Road" and the Yangtze River Economic Belt, YRD has the world's largest port clusters (Shanghai Port, Ningbo Zhoushan Port, etc.) and a dense transportation network, and its logistics industry accounts for more than 30% of the country's total, with an annual cargo volume of more than 20 billion tons. However, the rapid economic growth and the expansion of logistics demand have also brought about significant pressure on carbon emissions: carbon emissions from the transportation sector in YRD account for about 20% of the total regional emissions, with logistics activities contributing more than 60% of the total.

3.2 Results

3.2.1 Carbon emission efficiency

Based on the above data of input-output related indicators of the logistics industry, the carbon emission efficiency of the logistics industry in YRD from 2011 to 2021 is measured, and the results are shown in Table 3.

Table 3 Carbon Emission Efficiency of the Logistics Industry in YRD, 2011-2021

Region	Anhui	Zhejiang	Jiangsu	Shanghai
2011	0.2742	0.4517	0.2632	0.6324
2012	0.2493	0.4564	0.2714	0.6523
2013	0.5408	0.7008	0.2725	0.6173
2014	0.5271	0.7033	0.2851	0.6267
2015	0.5162	0.7117	0.2810	0.6604
2016	0.5141	0.7556	0.2856	1.7966
2017	0.4134	0.9635	0.2818	0.6693
2018	0.4072	1.0382	0.2504	0.6867
2019	0.4258	0.6691	0.2843	0.6215
2020	0.4235	1.4613	0.2868	0.6160
2021	0.5200	0.6691	0.2831	0.6254
average value	0.4374	0.7801	0.2769	0.7459

Table 3 shows that the average value of carbon emission efficiency of the logistics industry in YRD during the study period is about 0.56, with more obvious regional differences. Shanghai has the highest mean value of carbon emission efficiency (0.7459), which is closely related to its highly intensive logistics system (e.g., automated warehousing, popularization of new energy means of transport) and strict environmental protection policies. Zhejiang has the second highest average efficiency value (0.7801), but it fluctuates greatly due to the promotion of "smart logistics" pilot projects in Hangzhou and Ningbo and the expansion of carbon trading pilot projects. Anhui and Jiangsu have lower efficiency averages (0.4374 and 0.2769, respectively), reflecting the fact that the logistics industry in these two provinces still relies on traditional high-carbon modes, with a high proportion of road transportation and a coal-based energy structure. Jiangsu as a major manufacturing province, has logistics demand deeply tied to industrial activities, making low-carbon transition more difficult.

3.2.2 Measuring the intensity of environmental regulation

The calculation results of the environmental regulation intensity of the logistics industry in YRD from 2011 to 2021 are shown in Table 4.

Table 4 Measurement of Environmental Regulatory Intensity

Region	Shanghai		Jiangsu		Zhejiang		Anhui	
	ER1	ER2	ER1	ER2	ER1	ER2	ER1	ER2
2011	0.0106	0.0003	0.0008	0.0006	0.0088	0.0005	0.0095	0.0005
2012	0.0095	0.0005	0.0013	0.0007	0.0100	0.0008	0.0092	0.0006
2013	0.0082	0.0002	0.0007	0.0010	0.0095	0.0015	0.0096	0.0020
2014	0.0073	0.0007	0.0008	0.0007	0.0093	0.0016	0.0111	0.0007
2015	0.0077	0.0007	0.0008	0.0008	0.0094	0.0013	0.0121	0.0007
2016	0.0077	0.0017	0.0012	0.0009	0.0101	0.0012	0.0102	0.0015
2017	0.0077	0.0013	0.0009	0.0005	0.0104	0.0007	0.0108	0.0008
2018	0.0072	0.0002	0.0008	0.0008	0.0101	0.0006	0.0104	0.0005
2019	0.0074	0.0007	0.0009	0.0006	0.0106	0.0005	0.0108	0.0007
2020	0.0080	0.0002	0.0009	0.0005	0.0107	0.0007	0.0120	0.0006
2021	0.0065	0.0002	0.0006	0.0001	0.0007	0.0002	0.0101	0.0003

Overall, Anhui has long been a leader in command environmental regulation and, as a latecomer, has relied more on administrative tools such as mandatory closure of over-standardized firms and higher sewage charges to make up for the

lack of market mechanisms. Shanghai and Zhejiang have lower levels of command environmental regulation, but market incentive environmental regulation tools are widely used, reflecting a preference for market mechanisms to guide emissions reductions. In Jiangsu, the intensity of both types of regulation is low, probably because the policy design does no effectively combine the two types of tools, resulting in insufficient incentives to reduce emissions. The average value of market incentive environmental regulation in YRD is only 0.001, indicating that market-based tools such as emissions trading and green subsidies have not yet formed a scale effect in the logistics industry.

3.3 Empirical Analysis of Environmental Regulation on the Carbon Emission Efficiency of Logistics Enterprises

3.3.1 Descriptive statistical analysis of the sample

The descriptive statistical results are detailed in Table 5.

Table 5 Descriptive statistics of the sample

Item	Sample size	Minimum value	Maximum values	Average value	(statistics) Standard deviation	Upper quartile
Carbon emission efficiency	44	0.249	1.797	0.560	0.309	0.524
Command environmental regulation	44	0.001	0.012	0.007	0.004	0.009
Market-Incentivized Environmental Regulation	44	0.000	0.002	0.001	0.000	0.001
Level of human capital	44	0.016	0.025	0.020	0.002	0.021
Level of agency intervention	44	0.119	0.256	0.177	0.045	0.169
Level of financial development	44	2.202	6.291	3.761	1.289	3.384
Level of foreign investment	44	0.015	0.048	0.031	0.010	0.032
Level of technological innovation	44	0.061	1.010	0.309	0.225	0.253

3.3.2 Empirical analysis

Table 6 shows the results of a random effects test with logistics industry carbon emission efficiency as the dependent variable, two environmental regulatory tools, and five control variables as explanatory variables.

Table 6 Random effects model results

Item	Coef	Std.Err	*t*	*p*	95% CI
Command Environmental Regulation Tool	46.878	11.138	4.209	0.000**	25.047~68.708
Market incentive-based environmental regulation tools	253.761	125.051	2.029	0.050*	8.665~498.856
Level of technological innovation	1.249	0.558	2.238	0.032*	0.155 to 2.343
Level of foreign investment	15.023	7.266	2.068	0.046*	0.782~29.264
Level of financial development	0.118	0.016	7.593	0.000**	0.087~0.148
Level of agency intervention	-0.466	0.750	0.621	0.539	-1.936~1.004
Level of human capital	-45.067	26.067	1.729	0.092	-96.156~6.023

The random effects modeling results lead to the following conclusions.

First, the command environmental regulation tools have a positive and significant impact on the carbon emission efficiency of the logistics industry. It shows that the agency's introduction of mandatory policies is conducive to the regulation of logistics enterprises to improve themselves, improve the efficiency of their own carbon emissions to reduce carbon dioxide emissions, and reduce environmental pollution.

Secondly, market incentive environmental regulatory tools will have a significant positive impact on the carbon emission efficiency of the logistics industry. It shows that the agency's full use of market-based instruments (e.g., adjusting sewage charges, granting subsidies for energy-saving and emission reduction policies, and adjusting the proportion of taxes and fees for logistics enterprises) can effectively motivate logistics enterprises to take the initiative to make environmental protection-related strategic adjustments.

Third, the level of technological innovation has a significant positive impact on the carbon emission efficiency of the logistics industry. It indicates that the higher the technological innovation level of logistics enterprises themselves, the higher the carbon emission efficiency of the enterprises. This result is the same as most scholars' research results [25,26,27].

Fourth, the impact of foreign investment level on the carbon emission efficiency of the logistics industry is positively significant, indicating that the higher the level of foreign investment, the higher the carbon emission efficiency of the logistics industry will also increase. Foreign investment is often accompanied by the introduction of advanced

technology and management experience, which can improve the operational efficiency and energy utilization efficiency of logistics enterprises and thus reduce carbon emissions. Foreign investment may also change the energy structure of logistics enterprises, such as increasing the proportion of renewable energy used and reducing fossil energy consumption, thus reducing carbon emissions.

Fifth, the level of financial development will have a significant positive effect on the carbon emission efficiency of the logistics industry, indicating that as the level of financial development increases, the carbon emission efficiency of the logistics industry will also increase. This may be because the higher the financial development, the more it helps to reduce the financing cost of logistics enterprises and improve the convenience of financing. This makes it easier for logistics enterprises to obtain funds for technological upgrading, equipment renewal and green transformation, thus improving carbon emission efficiency.

Sixth, the regression coefficients of the degree of agency intervention and the level of human capital on the carbon emission efficiency of the logistics industry are negative, but neither of them passes the 5% significance test. This means that the view that the higher the degree of agency intervention will inhibit the initiative of logistics enterprises to reduce carbon emission efficiency is not confirmed. At the same time, it does not mean that the higher the level of human capital, the lower the carbon emission efficiency of the logistics industry.

4 SUGGESTIONS

4.1 Scientific Selection of Environmental Regulatory Instruments

According to the results of the study, command and market incentive environmental regulation tools will have a significant positive impact on the carbon emission efficiency of the logistics industry, the agency should weigh the pros and cons of different environmental regulations, and actively formulate the appropriate regulatory tools according to the specific development situation of different regions, so as to prescribe the right medicine for the problem. For example, in Zhejiang and Shanghai, where the level of economic development and marketization is relatively high, and the carbon emission efficiency of logistics enterprises is at a high level, the relatively low-cost market incentive environmental regulation tools can be chosen to reduce the impact of logistics enterprises on environmental pollution. For Jiangsu Province, although its level of economic development is high, the carbon emission efficiency of its logistics industry is significantly lower, so it should focus on command regulation, by improving the local environmental laws and regulations, and increasing the punishment for excessive emissions in the form of mandatory orders. In the management of carbon emissions in the logistics industry, command and market incentive environmental regulations should be combined to form a management system with complementary advantages. By setting strict carbon emission standards and strengthening policy enforcement, we can ensure that enterprises meet their emission reduction targets.

4.2 Strengthening Technological Innovation

The empirical results show that technological innovation has a significant positive impact on the carbon emission efficiency of the logistics industry, therefore, the agency should actively formulate relevant policies to encourage enterprises to strengthen the research on relevant energy-saving and emission reduction technologies, and encourage logistics enterprises to build an intelligent management system, strengthen human-computer interaction, and reduce management errors. Guiding enterprises from their own cost-effectiveness, exploring the nodes that can be optimized in each supply chain link, jointly building an intelligent supply chain management platform, reducing management costs, improving management efficiency, and thus promoting energy saving and emission reduction.

4.3 Improving Financial Development

Finance is the core of modern economy, and improving the level of financial development can help optimize the allocation of resources and improve the efficiency of the use of funds, thus promoting industrial upgrading, technological innovation and economic growth. According to the results of the study, the level of financial development has a significant positive impact on the carbon emission efficiency of the logistics industry, and the agency should formulate comprehensive measures to rationalize market regulation. For example, it can increase the investment in financial science and technology research and development, and encourage financial institutions to cooperate with science and technology enterprises to jointly promote financial science and technology innovation.

4.4 Increasing the Level of Foreign Investment

Foreign-invested enterprises usually have advanced technology and R&D capabilities. Through cooperation and exchanges with local enterprises, foreign investors can promote the exchange, dissemination and transfer of technology. This helps to improve the technical level and innovation ability of local enterprises to accumulate new recent and technical experience, thus promoting the upgrading and innovation of the whole industry. For the logistics industry, foreign enterprises can not only bring advanced enterprise management experience, but also may introduce advanced logistics management systems, automated warehousing equipment, low-carbon transportation technology, etc., all of which can help improve the overall carbon emission efficiency of the logistics industry.

5 CONCLUSION

This study selects the YRD as the sample, centers on the logistics industry, and uses the super - efficiency SBM model to measure the carbon emission efficiency of the logistics industry. It also empirically tests the effect paths of two types of environmental regulation tools (command and market incentive) through the random effects model. The aim is to uncover the mechanisms of environmental regulation and carbon emission efficiency in densely populated city clusters and provide scientific support for regional green development strategies.

This study finds that both command and market incentive environmental regulation tools significantly and positively affect the carbon emission efficiency of the logistics industry. Besides, improvements in technological innovation, foreign investment, and financial development levels also boost this efficiency. It enriches the perspective on the relationship between environmental regulation and industry specific carbon emission efficiency, offers a theoretical basis for agencys to formulate scientific and reasonable environmental regulation policies. Also, it helps guide logistics enterprises to strengthen innovation, increase carbon emission efficiency, and enhance market competitiveness, propelling the green development of the logistics industry in YRD.

However, the research has limitations. It doesn't fully consider the potential impact of factors like enterprise size and supply chain management on carbon emission efficiency and lacks dynamic analysis of the changing effects of environmental regulation policies over time. For future research, it's suggested to delve into the impact of enterprise - level factors on carbon emission efficiency, apply dynamic analysis methods, and evaluate the long - term effects of environmental regulation policies.

COMPETING INTERESTS

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DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

All authors contributed to the study conception and design. C.W.: Conceptualization, Methodology, Resources, Supervision. A.L.: Writing– original draft, Data curation, Formal analysis, Validation. All authors read and approved the final manuscript.

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CASE STUDY ANALYSIS OF 7P MARKETING STRATEGY APPLICATION

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Abstract: China's economy has rapidly recovered post-pandemic, driving a gradual rebound in the hotel industry. As a representative of mid-range chain hotels, LF Hotel has established a unique market advantage with its core philosophy of "friend-style service." However, its rapid expansion has led to inconsistent service quality across its outlets, exposing issues in seven key areas: product, price, place, promotion, people, process, and physical evidence. These challenges not only reflect the difficulties faced by LF Hotel but also highlight common marketing dilemmas in the mid-range chain hotel industry. This study, based on the 7P service marketing theory, designs and distributes questionnaires to conduct an in-depth investigation of LF Hotel's customer base, comprehensively analyzing its current service marketing status and existing problems. The research findings indicate that customer satisfaction with personnel, service processes, and physical evidence is relatively low, showing a significant gap compared to their psychological expectations. Based on these findings, targeted optimization strategies for service marketing are proposed, aiming to enhance LF Hotel's sustainable development capabilities while providing theoretical references and practical guidance for the mid-range chain hotel industry.
Keywords: Service marketing; LF hotel; 7P marketing strategy

1 INTRODUCTION

Over the past decade, China's economy has maintained steady growth, demonstrating a continuous upward trend. This economic growth has been accompanied by a profound shift in consumer attitudes, transitioning from a focus on material needs to a pursuit of spiritual fulfillment. High-quality service has gradually become a critical factor in market competition. As a mid-range chain hotel brand, LF Hotel has distinguished itself in the industry with its "friend-style service" philosophy, attracting significant attention from young consumers. However, with the rapid increase in the number of outlets, management challenges have escalated, and inconsistent service quality has become a major bottleneck in its development. These issues not only affect LF Hotel's brand image but also reflect common challenges faced by the mid-range chain hotel industry. From a theoretical perspective, existing research on hotel marketing has paid relatively little attention to the service marketing of mid-range chain hotels. This study takes LF Hotel as its research subject, systematically analyzing its service marketing based on the 7P service marketing theory [1], aiming to fill this research gap and enrich the theoretical framework of service marketing for mid-range chain hotels. From a practical perspective, optimizing service marketing strategies can effectively enhance customer satisfaction, strengthen market competitiveness, mitigate risks caused by service quality issues, and achieve sustained growth in revenue. Furthermore, the research findings are not only applicable to LF Hotel but also provide valuable insights for other mid-range chain hotels, contributing to the overall improvement of service standards in the industry. Therefore, this study holds significant practical importance.

1.1 Theoretical Foundation

The 7P service marketing theory (product, price, place, promotion, people, physical evidence, and process) [2]builds upon the traditional 4P framework by emphasizing service-specific elements. It highlights brand value enhancement through employee skill development, environmental detail optimization, and service process design. This study applies this theory to systematically analyze LF Hotel's current situation, proposing targeted optimization strategies such as improving personnel training systems, flexible pricing mechanisms, and integrating online and offline channels. These strategies provide theoretical support for the marketing upgrade of service-oriented enterprises [3].

1.2 Research Status

Internationally, Booms and Bitner established the 7P service marketing theory, followed by subsequent scholars proposing integrated marketing, digital applications, and green marketing. Dalia Marin empirically demonstrated the significant role of product advantages in driving marketing. Domestically, research has surged in the past five years, with scholars focusing on differentiation strategies, implementation challenges in underdeveloped regions, contactless services spurred by the pandemic, and employee incentives.

2 RESEARCH METHODOLOGY

2.1 Introduction to LF Hotel

LF Hotel (Lavande Hotel), established in 2013 under the Jinjiang Hotels Group, is a mid-range chain brand. It integrates lavender elements and fragrance culture into its hotel concept, creating a unique "friend-style service" experience, offering features such as hot towels, floral tea, white-glove service, and iPad room selection. As of now, LF Hotel has opened over 1,000 outlets across 314 cities, serving more than 30 million customers. Its locations are primarily near universities, reflecting its precise targeting of young consumer groups.

2.2 Questionnaire Design and Analysis

2.2.1 Survey design

The survey consisted of a 29-question questionnaire covering customer demographics, stay experiences, and evaluations. It included single-choice, multiple-choice, matrix scale, and open-ended questions. A total of 150 questionnaires were distributed, with 130 valid responses collected, yielding an effective response rate of 87%. Invalid responses were mainly due to incomplete answers or repetitive choices [4]. The survey targeted both customers who had stayed at LF Hotel and potential customers aware of but yet to stay at the hotel. Data collection was conducted online via WeChat and offline through QR codes at hotel outlets from March to April 2023. The survey aimed to provide a clear analysis of LF Hotel's current marketing status, collect authentic data, identify service marketing issues, and offer references for optimization strategies.

2.2.2 Data analysis

Table 1 Basic Information of Survey Respondents

Category	Options	Percentage
Gender	Male	35.29%
	Female	64.74%
Age	Below 23 years old	50.98%
	23-30 years old	19.61%
	31-40 years old	13.73%
	41-50 years old	9.8%
	Above 51 years old	5.88%
Location	Nanchong	15.69%
	Chengdu	35.29%
	Other areas within Sichuan	25.49%
	Areas outside Sichuan	23.53%
occupation	Government	11.75%
	Freelancer	19.61%
	Student	47.06%
	Corporate employee	15.69%
	Others	5.88%

	1500-2500	50.98%
Income Ranga	2500-5000	21.57%
	5000-8000	19.61%
	Above 8000	7.84%
Total	100%	

The sample characteristics were analyzed across five dimensions (See Table 1):
Gender: Males accounted for 35.29%, while females made up 64.74%, indicating a need to focus on female consumer preferences.
Age: 50.98% were under 23, and 19.61% were aged 23-30, reflecting a strong youth demographic (70%).
Residence: 35.29% were from Chengdu, 25.49% from other parts of Sichuan, and 23.53% from outside Sichuan, showing a concentration in the Sichuan region.
Occupation: 47.06% were students, and 19.61% were freelancers, together representing 66.67% of the sample, indicating a predominantly young demographic.
Monthly Income: 50.98% earned between 1,500-2,500 RMB, while only 7.84% earned above 8,000 RMB, reflecting limited consumer purchasing power.

2.2.3 Stay experience

Booking Channels: 76.47% booked through third-party apps (e.g., Meituan, Ctrip), while only 5.88% used the hotel's official WeChat account, indicating reliance on external platforms. Frequency of Stay: 41.86% had stayed 1-2 times, 16.28% had stayed 3 or more times, and 27.91% were potential customers, suggesting room for loyalty improvement.Product Experience: 67.74% used dining services, 41.94% used meeting facilities, while gym and self-service laundry usage was only around 16%, indicating insufficient promotion.Service Experience: 67.74% used luggage storage, and 38.71% used parking services, with other services being underutilized, highlighting a need for service diversity.

2.2.4 7P Problem analysis

Figure 1 7P Marketing Strategy

Product: Low utilization of facilities, with customers unaware of services like the gym, necessitating better promotion and guidance (See Figure 1).
Price: 61% were satisfied with room prices, and 64.5% were satisfied with app discounts, but 55% considered pricing high, indicating inflexibility.
Channel: 77% relied on third-party platforms, with low usage of the hotel's own channels (e.g., WeChat), and inadequate review response mechanisms.
Promotion: 16% were unaware of LF Hotel, with promotional efforts being monotonous and lacking innovation and broad coverage.
Personnel: Uneven age and education levels among staff, with front desk employees being young but inconsistent in quality, coupled with unprofessional training and high turnover.
Service process: Check-in satisfaction was 70%, while check-out satisfaction was only 60%, with deficiencies in reservation and room service details requiring process improvements.
Physical Evidence: 65% were satisfied with room environments, but 78% found the design outdated, lacking

innovation.

3 DISCUSSION OF PROBLEM CAUSES AND OPTIMIZATION STRATEGIES

3.1 Problem Causes

Inadequate Management Follow-Up: Rapid expansion has increased the difficulty of standardizing services, with uneven allocation of management resources [5]. Employee Quality Shortcomings: Incomplete training systems, lack of professional assessments, insufficient incentives, and high employee turnover. Lagging Marketing Strategies: Promotional efforts and channel development lack targeting, failing to fully tap into the consumption habits of young groups. Customer Expectation Gaps: Service processes and physical evidence do not align with modern consumer demands (e.g., technological integration, personalization).

3.2 Optimization Strategies

Promotion Strategy: Leverage new media platforms like Douyin and Kuaishou to create creative videos and live-streaming sales events, utilizing employees' personal accounts to expand brand awareness. People Strategy: Implement categorized training for all employees, combining departmental-specific guidance with practical case studies, and conduct regular assessments. Enhance incentives through improved benefits, bonuses, and promotion mechanisms, fostering a sense of belonging.Physical Evidence Strategy [6]: Update facility photos, strengthen staff appearance training, and integrate technological elements. Focus on intangible service details, such as professional front desk interactions, to enhance customer perception.Process Strategy: Optimize check-in by offering hot tea and inquiring about sleep preferences and floor choices. During stays, provide tailored services like fruit for tourists and quiet environments for business travelers. Improve reservations by training staff to record customer needs and send reminders about routes and weather [7]. Enhance check-out by proactively providing parking tickets, collecting feedback, and establishing big data follow-up mechanisms (e.g., birthday discounts, calendar mailings).

4 CONCLUSION

Guided by the 7P service marketing theory, this study conducted an empirical analysis of LF Hotel’s service marketing strategies through a structured questionnaire survey. The findings systematically revealed challenges across seven dimensions [8]: product design (e.g.lack of service differentiation), pricing mechanisms (inflexible dynamic adjustments), channel integration (weak coordination between online and offline platforms), promotional effectiveness (limited digital engagement), staff competency (inconsistent service standards) [9], service processes (inefficiencies in check-in/check-out), and physical evidence (underwhelming brand ambiance). To address these gaps, targeted strategies were proposed, including personalized service packages, AI-driven dynamic pricing, omnichannel customer journey optimization, and employee empowerment programs. These measures aim to enhance service quality, strengthen brand competitiveness, and align with sustainable development goals for the mid-range hotel sector.

Theoretically, this research enriches the application of the 7P framework in China’s hospitality industry, particularly for chain hotels facing homogenized competition. Practically, it provides actionable insights for LF Hotel to improve customer experience and achieve premium pricing, while serving as a reference model for peers to balance standardization and innovation [10].

Future studies should focus on three directions: First, longitudinal tracking of LF Hotel’s strategy implementation to establish a dynamic “problem identification-optimization-evaluation” cycle; Second, comparative analyses of mid-range chain hotels across regions to identify industry-wide bottlenecks and localized solutions; Third, exploration of emerging technologies (e.g., AI, IoT-enabled contextual marketing) to redefine service delivery and theoretical frameworks. Such efforts will foster agile adaptations to evolving market demands and technological disruptions.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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