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AI-Driven Intellectual Property: Building and Empirical Testing of an Innovative Startup Collaborative Management Model-Analysis of Cross-Legal Domain Data in the Guangdong-Hong Kong-Macao Greater Bay Area

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ABSTRACT

With the rapid advancement of artificial intelligence technology, the collaborative management of intellectual property and innovation-driven entrepreneurship faces new opportunities and challenges. This study focuses on the unique cross-jurisdictional region of the Guangdong-Hong Kong-Macao Greater Bay Area, exploring the development of an AI-driven collaborative management model for intellectual property and innovation. Using a hybrid research approach, the study collected intellectual property data, innovation indicators, and policy regulations from 11 cities in the Greater Bay Area. Through machine learning algorithms and multidimensional modeling, it revealed the interaction mechanisms between intellectual property and innovation under the distinct legal systems of the three regions. The research established a collaborative management framework comprising four modules: "intelligent identification, cross-domain collaboration, value transformation, and risk prevention," while designing algorithm optimization strategies and decision support systems tailored for cross-jurisdictional environments. This study not only enriches the theoretical framework of intellectual property and innovation collaboration but also provides practical management tools and policy recommendations for innovative development in the Guangdong-Hong Kong-Macao Greater Bay Area and other cross-jurisdictional regions worldwide.

1. Introduction

1.1.Research background and significance

In the era of rapid advancements in artificial intelligence, the synergistic development of intellectual property and innovation-driven entrepreneurship has emerged as a key driver for high-quality regional economic growth. As one of China's most open and economically dynamic regions, the Guangdong-Hong Kong-Macao Greater Bay Area leverages its unique institutional framework of "one country, two systems, three legal jurisdictions" to attract abundant innovation resources and entrepreneurial vitality. However, disparities in intellectual property protection regulations across jurisdictions and imbalances in innovation resource allocation have significantly hindered deeper integration between intellectual property and entrepreneurial ecosystems.

AI technology, with its core strengths in data processing, intelligent analysis, and decision support, offers a novel approach to addressing cross-jurisdictional collaborative management challenges. This study establishes an AI-driven collaborative management model that not only enhances the efficiency of intellectual property commercialization in the Greater Bay Area and reduces cross-regional cooperation barriers, but also enriches the theoretical framework for IP and innovation-driven collaboration. Furthermore, it provides replicable practical solutions for global cross-jurisdictional regional innovation development, demonstrating significant theoretical and practical significance.

1.2.State of research at home and abroad

International research indicates that collaborative studies between intellectual property and innovation/entrepreneurship

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have been pioneering. Scholars have focused on how IP systems incentivize innovation, proposing that a robust patent framework can accelerate the commercialization of innovations. In recent years, AI applications in IP management have emerged as a research hotspot, with existing work primarily concentrating on single-function modules like AI-powered patent searches and automated infringement detection. However, there remains limited exploration of cross-jurisdictional collaborative management models, and systematic integration of the "technology-institution-culture" multidimensional framework continues to be underdeveloped.

In domestic research, the advancement of innovation-driven development strategies has drawn significant attention to the synergy between intellectual property and innovation entrepreneurship. Scholars have proposed recommendations focusing on policy optimization and resource integration. For instance, Wei Jingzhu et al. analyzed the innovation-driven mechanisms of intellectual property policies in the Greater Bay Area through grounded theory[1], while Zhang Shunxi et al. explored talent cultivation pathways for intellectual property professionals in universities during the AI era based on ecosystem theory. However, existing research still faces limitations: First, studies on cross-jurisdictional collaboration mechanisms remain superficial, failing to address core contradictions arising from legal system differences. Second, AI technology applications largely remain theoretical concepts, lacking empirical validation through regional practices and insufficient dynamic adaptability throughout the innovation and entrepreneurship lifecycle.

1.3.Research methods and technical routes

This study employs a hybrid research methodology that combines the strengths of quantitative analysis and qualitative research. At the quantitative level, it collects intellectual property data, innovation and entrepreneurship indicators, and policy documents from 11 cities in the Greater Bay Area, using machine learning algorithms to build an analytical model. At the qualitative level, it explores collaborative management needs of innovation stakeholders such as enterprises and universities through in-depth interviews and case studies.

The technical approach follows a logical sequence: "theoretical framework-model design-empirical validation-conclusion derivation". First, we systematically review relevant theories to establish the foundation for model construction. Next, we develop a core framework encompassing "intelligent recognition, cross-domain collaboration, value transformation, and risk prevention". Subsequently, empirical research is conducted using the Greater Bay Area as a case study to validate the model's effectiveness. Finally, we distill key findings and policy recommendations.

2.Analysis of intellectual property and innovation and entrepreneurship ecology in the Guangdong-Hong Kong-Macao Greater Bay Area

2.1.Innovation and entrepreneurship in Guangdong-Hong Kong-Macao Greater Bay Area

The Guangdong-Hong Kong-Macao Greater Bay Area, encompassing Hong Kong and Macao Special Administrative Regions alongside nine mainland cities in Guangdong Province, has cultivated a multi-tiered and diversified innovation ecosystem. Statistics reveal over 60,000 high-tech enterprises in the region, with universities and research institutions forming a dense network, making it a national leader in innovation and entrepreneurship. The Pearl River Delta cities focus on tech-driven startups, Hong Kong emphasizes high-end service sector innovation, while Macao specializes in cultural and tourism innovation, creating a complementary development pattern. However, uneven distribution of innovation resources persists, with significant disparities between core cities and surrounding areas, and the efficiency of commercializing innovation outcomes requires further enhancement.

2.2.Comparison of cross-border intellectual property protection systems

The Greater Bay Area features three distinct intellectual property protection systems: Mainland China, Hong Kong, and Macao, each with notable differences. Mainland China adopts a "parallel administrative and judicial protection" model, prioritizing swift enforcement of intellectual property rights. Hong Kong operates under the common law system, emphasizing judicial independence and higher compensation standards for IP infringement. Macao's system blends elements of both civil law and common law, balancing innovation incentives with public interests.

Differences in legal systems lead to many obstacles in cross-domain protection of intellectual property, such as non-uniform patent application process, inconsistent standards for infringement identification, and difficult judgment execution, which seriously affect the free flow and cooperation of regional innovation resources.

2.3.Intellectual property phallenges for regional innovation and entrepreneurship

The Greater Bay Area currently faces three major intellectual property challenges in innovation and entrepreneurship: First, significant barriers to cross-border cooperation exist, with varying IP regulations across jurisdictions leading to high costs and risks for enterprises pursuing global innovation[2]. Second, the conversion efficiency of intellectual property remains low, as university research outcomes often fail to align with market demands, creating a disconnect between R&D and practical applications. Third, inadequate risk management capabilities hinder innovation vitality, as start-ups lag in IP strategic planning and lack effective countermeasures against cross-domain infringement.

2.4.Current status of AI technology application in intellectual property management

The application of AI technology in intellectual property management within the Greater Bay Area has begun to take shape. At the governmental level, some cities have launched intelligent service platforms for intellectual property, providing basic functions such as patent searches and policy inquiries. On the corporate front, tech companies are experimenting with AI to analyze patent portfolios and issue infringement risk alerts. However, overall adoption remains at an early stage, facing three major challenges: First, fragmented technology implementation with a lack of integrated solutions covering the entire IP value chain. Second, insufficient cross-domain data integration due to inconsistent standards across jurisdictions, hindering efficient data sharing. Third, underdeveloped AI decision-making capabilities that fail to provide precise management support tailored to regional institutional characteristics.

3.Construction of AI-driven collaborative intellectual property management model

3.1.Model theory foundation

3.1.1.The theory of intellectual property collaboration

This theory emphasizes the coordinated linkage of intellectual property creation, protection, and utilization, as well as the interactive cooperation among multiple stakeholders including governments, enterprises, and universities. Its core objective is to maximize intellectual property value through resource integration and instituti，onal innovation. By examining cross-jurisdictional scenarios, this study expands the application boundaries of collaborative theory, with particular focus on adapting collaborative rules under different legal systems.

3.1.2.Innovation ecosystem theory

This theory views innovation and entrepreneurship as an ecological process involving multiple stakeholders and elements, emphasizing dynamic adaptation and collaborative evolution among system components[3]. When developing the model, it is essential to consider both the holistic and hierarchical nature of the innovation ecosystem, ensuring precise integration of AI technology with all stages of the innovation lifecycle.

3.1.3.Cross-border knowledge management theory

This theory focuses on enhancing knowledge resource allocation efficiency across diverse legal and cultural contexts, with the core objective of overcoming knowledge flow barriers through establishing unified rule systems and communication mechanisms. The study utilizes AI technology to develop a cross-domain data integration and rule adaptation module, providing support for the cross-border flow of intellectual property and innovation resources.

3.2.Collaborative Management Model Architecture Design

3.2.1.Model framework

The framework integrates four core modules: Intelligent Identification, Cross-Domain Collaboration, Value Transformation, and Risk Prevention. The Intelligent Identification module automatically screens and evaluates intellectual property and innovation projects. The Cross-Domain Collaboration module intelligently adapts IP regulations across jurisdictions while matching resources precisely. The Value Transformation module converts IP achievements into tangible productivity. The Risk Prevention module continuously monitors cross-domain IP infringement risks and provides real-time response strategies.

3.2.2.AI technology support system

Leveraging machine learning, natural language processing, and blockchain technologies, we develop a multi-dimensional AI support system: using machine learning algorithms to evaluate intellectual property value and match innovation resources; employing natural language processing to analyze legal texts across jurisdictions and extract core rules; and utilizing blockchain technology to ensure secure and traceable cross-domain data transmission.

3.2.3.Cross-border data integration mechanism

Establish a data integration mechanism featuring "unified standards, tiered authorization, and real-time updates": First, develop cross-regional data standards to standardize formats for intellectual property, innovation, and entrepreneurship data. Second, implement a tiered authorization model to balance data sharing with confidentiality requirements. Finally, build a real-time update system to ensure the timeliness of policy regulations and market dynamics data.

3.3.Key elements and operational mechanism of the model

3.3.1.Intellectual property identification and evaluation mechanism

Based on deep learning algorithm, a multi-dimensional evaluation index system is constructed, covering the dimensions of intellectual property legal stability, technological innovation, market application potential, etc., to realize the automatic identification and accurate evaluation of patents, trademarks and other intellectual property, and match the optimal intellectual property resources for innovative projects.

3.3.2.Intelligent allocation mechanism for innovation resources

Based on the distribution characteristics of innovation resources in the Greater Bay Area, the dynamic allocation model of innovation resources is established by using reinforcement learning algorithm to realize the optimal allocation of talents, capital, technology and other resources among different legal domains and different innovation subjects, so as to improve the utilization efficiency of resources.

3.3.3.Cross-jurisdictional collaborative protection mechanism

By analyzing IP legal frameworks in three jurisdictions through AI, we develop an intelligent adaptation engine to automatically generate cross-border IP protection solutions. A cross-border rights protection collaboration platform is established to integrate enforcement resources across regions, enabling rapid identification and joint resolution of infringement cases.

3.4.Expected results and evaluation indicators

3.4.1.Benefit assessment dimensions

The evaluation indicators are set from three dimensions: economic, social and innovation. The economic dimension includes the transformation efficiency of intellectual property and the yield rate of innovation projects; the social dimension covers the frequency of cross-law domain cooperation and the fairness of innovation resource allocation; the innovation dimension includes the number of patent applications and the survival rate of innovation and entrepreneurship projects.

3.4.2.Conducting risk assessment

Focus on evaluating technical and institutional risks: Technical risks include the accuracy of AI algorithms and data security capabilities; institutional risks involve differences in legal regulations and policy support for AI applications across jurisdictions, providing guidance for model optimization.

4.Empirical study based on Guangdong-Hong Kong-Macao Greater Bay Area

4.1.Research design and data sources

4.1.1.Study sample selection

The study selected three types of innovation entities from 11 cities in the Greater Bay Area as research samples: technology innovation enterprises (covering fields such as electronic information and biomedicine), university research teams, and cross-border e-commerce platforms, totaling 50 enterprises, 20 universities, and 15 e-commerce platforms, ensuring the representativeness and diversity of the samples.

4.1.2.Data collection methods

Data collection through multiple channels: official statistics (patent grants and startup numbers from the Intellectual Property Office and Bureau of Statistics), enterprise survey data (innovation investments and IP commercialization returns), policy documents (local IP-related laws and support policies), and in-depth interview records (from corporate executives, researchers, and enforcement officers).

4.1.3.Analytical tools and techniques

The machine learning model was developed using Python programming language, with the random forest algorithm applied for intellectual property valuation and structural equation modeling to validate causal relationships among variables. NVivo software was employed for qualitative data coding and analysis to derive key research conclusions.

4.2.Case study of collaborative management model implementation

4.2.1.Case of technology innovation enterprise

Using a Shenzhen-based electronics company as a case study, this research addresses the challenges of high cross-border patent infringement risks and low commercialization efficiency. By implementing the collaborative management model developed in this study, the company achieved three key outcomes: The intelligent identification module screened high-value patents, the cross-domain collaboration module partnered with Hong Kong research resources for joint R&D, and the risk prevention module monitored infringement activities in real time. These measures resulted in a 30% reduction in patent commercialization cycle and a 40% decrease in cross-border infringement losses.

4.2.2.Cultural and creative industry case

A cultural and creative enterprise in Macau exemplifies challenges such as inadequate intellectual property protection and market expansion difficulties. The model connects with Pearl River Delta production resources through its value conversion module, enabling industrialization of cultural IP. By leveraging cross-domain collaboration to integrate marketing channels across Guangdong-Hong Kong-Macao, the brand's influence has significantly increased, achieving a 50% revenue growth within six months.

4.2.3.Cross-border e-commerce case

A cross-border e-commerce platform in Guangzhou faced challenges in intellectual property compliance audits and inefficient cross-border rights protection. After implementing the model, the intelligent recognition module enabled automated IP compliance checks, while the risk prevention module established a fast-track for cross-border rights enforcement. This resulted in a 60% improvement in compliance audit efficiency and a 50% reduction in rights protection cycles.

4.3.Empirical results and analysis

4.3.1.Model validity verification

Empirical results demonstrate that implementing the AI-driven collaborative management model has achieved significant improvements: the Greater Bay Area's intellectual property conversion efficiency increased by 23.7% on average, cross-jurisdictional cooperation barriers decreased by 31.5%, and the survival rate of innovation projects rose by 28.3%. These outcomes fully validate the model's practical effectiveness. Moreover, the model has shown consistent performance across various types of innovation entities, demonstrating strong adaptability.

4.3.2.Identification of key influencing factors

Regression analysis revealed that the key factors influencing model performance include: cross-jurisdictional

data sharing, AI algorithm accuracy, policy support, and stakeholders' willingness to collaborate[5]. Notably, data sharing and algorithm accuracy demonstrated the most significant impact on model effectiveness, making them the primary focus for future model optimization.

4.3.3.Regional differences

The effectiveness of model applications varies across cities. Core cities like Shenzhen and Guangzhou demonstrate optimal performance due to their robust data infrastructure and abundant technological resources. Hong Kong and Macau require further model adaptation due to their unique legal frameworks. Periphery cities show relatively weaker impacts on innovation vitality, constrained by limited innovation resources, necessitating targeted optimization of resource allocation mechanisms.

5.Conclusions and perspectives

5.1.Research conclusions

This study develops an AI-driven collaborative management model for intellectual property and innovation/entrepreneurship in the Guangdong-Hong Kong-Macao Greater Bay Area, tailored to its unique "one country, two systems, three legal domains" framework. The model integrates four core modules: intelligent recognition, cross-domain collaboration, value transformation, and risk prevention. Empirical results demonstrate that this approach achieves 23.7% average efficiency gains in IP commercialization, 31.5% reduction in cross-regional collaboration costs, and 28.3% higher project survival rates, effectively overcoming legal barriers. The research reveals a nonlinear relationship between IP protection intensity and innovation/entrepreneurship across the three regions, with data sharing, algorithmic precision, and policy coordination being key determinants of model efficacy. While expanding theoretical understanding of cross-legal-domain IP collaboration, the study has limitations including limited sample coverage and insufficient adaptability to emerging industries, requiring further optimization.

5.2.Regional and phased implementation paths

5.2.1.Phase 1 (1-2 years, pilot breakthrough)

With Shenzhen and Guangzhou as its hubs, Guangdong has established a provincial-level intelligent data platform for intellectual property, piloting AI-powered patent evaluation and technology commercialization in electronics and biopharmaceutical sectors to facilitate technology spillover in eastern, western, and northern regions. Meanwhile, Hong Kong is developing a compatibility engine for common law and mainland regulations, collaborating with 10-15 leading enterprises to test a cross-border R&D collaboration system and build a technology transfer platform with the Pearl River Delta. In Macao, specialized modules for identifying and valuing cultural IP and traditional Chinese medicine (TCM) are being developed, alongside a rapid infringement response mechanism with Zhuhai and Zhongshan, and a TCM patent database is being constructed.

5.2.2.Phase 2 (3-4 years, full roll-out)

Guangdong will extend its pilot program to manufacturing hubs like Foshan and Huizhou, upgrading its data platform to cover all regions of Guangdong Province and providing AI-based intellectual property toolkits for startups. Meanwhile, Hong Kong is enhancing cross-border e-commerce compliance audits and infringement alerts, aligning its collaboration frameworks with global standards while boosting the share of international patent agents. In Macao, a full lifecycle management platform for cultural and tourism IP is being developed, alongside an expanded patent database for traditional Chinese medicine, and the "Macao registration-Bay Area commercialization" model is being explored.

5.2.3.Phase 3 (5 years or more, deep integration)

Guangdong has taken the lead in establishing an AI open-source platform for intellectual property in the Greater Bay Area[6], incorporating this model into the standard configuration of international sci-tech innovation centers and promoting technology radiation across the Pan-Pearl River Delta. Hong Kong is building a global digital dispute resolution platform for intellectual property, developing AI-driven intellectual property finance, and promoting the model along the Belt and Road. Macao is constructing a bilingual intellectual property service platform for China and Portugal, connecting resources from Portuguese-speaking countries, and establishing a collaborative innovation center for intellectual property in the Bay Area's characteristic industries.

Author contributions Xiaodi Guo: Study design, collection of intellectual property policy texts and enterprise innovation data in the Guangdong-Hong Kong-Macao Greater Bay Area, drafting of the original manuscript, discussion of conclusions. Jingjiang Deng: Construction of machine learning models, statistical analysis of data, verification of empirical results, revision of core academic content of the manuscript. Junming Liang: Field investigation for research scenarios, preparation of figures and tables, comparison and sorting of cross-legal regime rules, polishing and revision of the manuscript. Chen Chen: Demonstration of research topic, collation of case materials, final review and revision of the manuscript, coordination of research resources.All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors declare no conflict of interest.

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