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Article

Economic Value and Technological Synergy of Urban Low-Altitude Transportation Infrastructure: A Global Comparative Study

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ABSTRACT

With the rapid development of the low-altitude economy, urban low-altitude transportation infrastructure has become a key driver of urban economic growth and transportation system upgrading. This study explores the economic value and technological synergy mechanism of urban low-altitude transportation infrastructure through global comparative analysis. By examining 12 pilot cities in China, the United States, and the European Union, the research evaluates the economic impact of infrastructure construction from the perspectives of investment return, industrial agglomeration, and employment promotion. Meanwhile, it analyzes the integration and application of core technologies such as digital twin, 5G-A communication, and Beidou navigation in infrastructure operation. The results show that modular low-altitude take-off and landing facilities and intelligent air traffic management systems can improve airspace resource utilization by 25%-35% and reduce operational costs by 18%-22%. Policy suggestions are put forward to promote the sustainable development of low-altitude transportation infrastructure, including improving the hierarchical airspace management system and strengthening cross-regional technological cooperation. This study provides theoretical and practical references for the planning and construction of urban low-altitude transportation infrastructure worldwide.

Keywords: Urban low-altitude airspace; Transportation infrastructure; Economic value; Technological synergy; Digital twin; Low-altitude economy

1. Introduction

1.1 Research Background

In recent years, the low-altitude economy has emerged as a new engine driving global economic growth, with urban low-altitude transportation as its core component. Urban low-altitude transportation infrastructure, including unmanned aerial vehicle (UAV) take-off and landing sites, intelligent air traffic management systems, and communication navigation facilities, is the foundation for the large-scale development of low-altitude logistics, urban air mobility (UAM), and emergency rescue services. With the acceleration of urbanization, ground traffic congestion has become a common problem worldwide, and the development of low-altitude airspace has opened up new space for urban transportation optimization. Countries around the world have successively launched relevant policies to promote the construction of low-altitude transportation infrastructure. For example, China has opened low-altitude airspace below 600 meters in six pilot cities including Hefei, Hangzhou, and Shenzhen, and incorporated the low-altitude economy into the category of new quality productive forces; the European Union has carried out a series of UAM demonstration projects through the Single European Sky ATM Research (SESAR) program; the United States Federal Aviation Administration (FAA) has formulated a phased development plan for urban air traffic management.

However, the construction and operation of urban low-altitude transportation infrastructure still face many challenges. On the one hand, the high investment cost of infrastructure and the uncertainty of economic returns have restricted the enthusiasm of social capital participation; on the other hand, the integration level of core technologies such as air traffic control, communication navigation, and intelligent scheduling is not high, which affects the operational efficiency and safety of infrastructure. In addition, the lack of a unified international airspace management standard and the imperfect supporting policy system have also become important factors hindering the cross-regional and large-scale development of low-altitude transportation infrastructure. Therefore, exploring the economic value of urban low-altitude transportation infrastructure and clarifying the synergy mechanism of related technologies is of great significance for promoting the healthy development of the low-altitude economy and optimizing the urban transportation system.

1.2 Research Objectives and Questions

The main objective of this study is to systematically explore the economic value and technological synergy mechanism of urban low-altitude transportation infrastructure, and put forward targeted policy suggestions for its sustainable development. To achieve this objective, the following research questions are proposed: (1) What are the main components and functional characteristics of urban low-altitude transportation infrastructure? (2) What is the economic impact of urban low-altitude transportation infrastructure construction on urban economy, including investment return, industrial agglomeration, and employment promotion? (3) How to realize the synergy of core technologies such as digital twin, 5G-A communication, and Beidou navigation in the operation of low-altitude transportation infrastructure? (4) What policy measures are needed to promote the healthy development of urban low-altitude transportation infrastructure in different countries and regions?

1.3 Research Significance

From a theoretical perspective, this study enriches the research on the economic value of transportation infrastructure by focusing on the emerging field of low-altitude transportation infrastructure, and constructs a theoretical framework for the technological synergy of low-altitude transportation infrastructure, which provides a new perspective for the interdisciplinary research of urban economics, transportation engineering, and information technology. From a practical perspective, by comparing the construction and operation experiences of low-altitude transportation infrastructure in different countries and regions, this study clarifies the key factors affecting the economic benefits and operational efficiency of infrastructure, and puts forward feasible policy suggestions, which can provide decision-making references for governments, enterprises, and research institutions to carry out low-altitude transportation infrastructure planning and construction. In addition, the research results can also promote the standardized development of the global low-altitude economy and enhance the competitiveness of cities in the new round of technological revolution and industrial transformation.

1.4 Research Structure

This paper is structured as follows: Section 2 reviews the relevant literature on low-altitude economy, urban low-altitude transportation infrastructure, and technological synergy, and clarifies the research gap. Section 3 introduces the research methodology, including the selection of research cases, data collection methods, and analytical framework. Section 4 analyzes the composition and functional characteristics of urban low-altitude transportation infrastructure, and constructs an evaluation index system for its economic value. Section 5 explores the technological synergy mechanism of low-altitude transportation infrastructure through case studies of pilot cities in different countries. Section 6 discusses the policy challenges faced by the development of low-altitude transportation infrastructure and puts forward corresponding policy suggestions. Section 7 summarizes the main research conclusions, points out the research limitations, and looks forward to future research directions.

2. Literature Review

2.1 Low-Altitude Economy and Urban Transportation Transformation

The concept of the low-altitude economy was first proposed in China, referring to an economic form that takes low-altitude airspace as the resource carrier and relies on low-altitude aircraft and related technologies to carry out economic activities such as transportation, tourism, and logistics. Scholars at home and abroad have carried out a series of researches on the connotation, characteristics, and development path of the low-altitude economy. For example, Li et al. (2023) pointed out that the low-altitude economy has the characteristics of high technological content, strong industrial driving force, and wide coverage of application scenarios, and is an important direction for the transformation and upgrading of the transportation industry. Smith and Johnson (2024) transportation carbon emissions, and promote the integrated development of urban and rural areas.

In the research on the relationship between low-altitude economy and urban transportation transformation, most scholars believe that urban low-altitude transportation is an important part of the future urban transportation system and will profoundly change the urban spatial structure and transportation mode. For example, Zhang et al. (2025) pointed out that the integration of urban low-altitude transportation and ground transportation can form a three-dimensional transportation network, which is of great significance for optimizing the urban transportation structure and improving transportation efficiency. However, existing studies mostly focus on the macro impact of the low-altitude economy on urban transportation, and there is a lack of in-depth analysis on the role of low-altitude transportation infrastructure as the core carrier.

2.2 Economic Value Evaluation of Transportation Infrastructure

The economic value of transportation infrastructure has always been a hot topic in the field of urban economics. Traditional research mainly focuses on the economic impact of ground transportation infrastructure such as highways, railways, and airports. For example, Aschauer (1989) put forward the „public capital hypothesis", believing that transportation infrastructure investment can significantly promote economic growth by improving factor productivity. With the development of the aviation industry, scholars have begun to pay attention to the economic value of aviation infrastructure. For example, Button and Yuan (2023) evaluated the economic benefits of general aviation airports in Europe and found that they can promote the agglomeration of related industries and increase employment opportunities in the region.

In recent years, with the rise of the low-altitude economy, a small number of scholars have begun to explore the economic value of low-altitude transportation infrastructure. For example, Jia et al. (2025) constructed an economic benefit evaluation model for UAV take-off and landing sites and found that the investment return period of such infrastructure is about 3-5 years in logistics and emergency rescue scenarios. However, existing research on the economic value of low-altitude transportation infrastructure is still in its infancy, with problems such as incomplete evaluation indicators and single research methods. Most studies only focus on direct economic benefits such as investment return, while ignoring indirect economic benefits such as industrial agglomeration and technological spillover.

2.3 Technological Synergy in Low-Altitude Transportation Infrastructure

The operation of urban low-altitude transportation infrastructure relies on the integration and synergy of multiple technologies such as air traffic management, communication navigation, and intelligent scheduling. Scholars have carried out relevant researches on the application of individual technologies in low-altitude transportation. For example, Wang et al. (2024) studied the application of digital twin technology in urban airspace management and found that it can improve the accuracy of airspace monitoring and the efficiency of traffic scheduling. Garcia and Rodriguez (2023) 5G communication technology real-time communication and data transmission, ensuring the safety and efficiency of logistics operations.

However, there are few studies on the technological synergy mechanism of low-altitude transportation infrastructure. Most studies focus on the application of a single technology, while ignoring the interaction and synergy effect between different technologies. In addition, the existing research on technological application mostly stays at the theoretical level, and there is a lack of in-depth analysis based on practical cases. Therefore, it is necessary to systematically explore the technological synergy mechanism of low-altitude transportation infrastructure through global comparative case studies.

2.4 Research Gap

To sum up, the existing research has laid a certain theoretical foundation for the study of urban low-altitude transportation infrastructure, but there are still obvious research gaps: (1) The research on the economic value of low-altitude transportation infrastructure is not comprehensive enough, lacking a systematic evaluation system that covers both direct and indirect economic benefits. (2) There is a lack of in-depth research on the technological synergy mechanism of low-altitude transportation infrastructure, and the interaction between different core technologies has not been clarified. (3) Most studies are based on a single country or region, and there is a lack of global comparative analysis, which makes it difficult to put forward universal policy suggestions. This study will focus on filling these research gaps and carry out in-depth research on the economic value and technological synergy of urban low-altitude transportation infrastructure.

3. Research Methodology

3.1 Research Design

This study adopts a mixed research method combining case study and comparative analysis. Case study is conducive to in-depth exploration of the economic value and technological synergy mechanism of low-altitude transportation infrastructure in specific scenarios, while comparative analysis can reveal the similarities and differences in the development of low-altitude transportation infrastructure in different countries and regions, and improve the universality of research conclusions. This study selects 12 pilot cities from China, the United States, and the European Union as research cases, covering different economic development levels, policy environments, and technological application levels, to ensure the representativeness and diversity of the cases.

3.2 Case Selection

The selection of case cities follows the principles of typicality, representativeness, and data availability. Specifically, 4 pilot cities are selected from each of China, the United States, and the European Union: (1) China: Hangzhou, Shenzhen, Hefei, Chengdu (these cities are the first batch of low-altitude economy pilot cities in China, with relatively mature low-altitude transportation infrastructure construction and rich operational experience); (2) United States: Los Angeles, Dallas, Miami, Boston (these cities have carried out a number of UAM demonstration projects and have a sound aviation industry foundation); (3) European Union: Berlin (Germany), Amsterdam (Netherlands), Paris (France), Barcelona (Spain) (these cities are important nodes of the European UAM development plan and have advanced technological research and development capabilities in the field of low-altitude transportation).

3.3 Data Collection Methods

The data in this study mainly comes from three aspects: (1) Secondary data collection: collecting relevant policy documents, industry reports, and academic papers from governments, international organizations (such as EASA, FAA), and industry associations of various countries, to understand the policy environment, development status, and economic data of low-altitude transportation infrastructure in each case city; (2) Field investigation: conducting field investigations on the low-altitude transportation infrastructure facilities (such as UAV take-off and landing sites, intelligent air traffic management centers) in 12 case cities, collecting first-hand data on infrastructure construction scale, investment amount, operational efficiency, and technological application; (3) Expert interviews: interviewing 30 experts from government departments, aviation enterprises, research institutions, and universities in various countries, including policy makers, enterprise managers, and technical researchers, to obtain in-depth information on the economic benefits, technological challenges, and policy needs of low-altitude transportation infrastructure.

3.4 Analytical Framework

This study constructs a two-dimensional analytical framework of „economic value-technological synergy“ to analyze urban low-altitude transportation infrastructure. In the economic value dimension, from the perspectives of direct economic benefits (investment return, operational income) and indirect economic benefits (industrial agglomeration, employment promotion, technological spillover), an evaluation index system is constructed to measure the economic impact of infrastructure construction. In the technological synergy dimension, taking digital twin, 5G-A communication, Beidou/GPS navigation, and intelligent scheduling as core technologies, the synergy effect and implementation path of each technology in infrastructure operation are analyzed. On this basis, through cross-case comparison, the differences in economic value and technological synergy of low-altitude transportation infrastructure in different countries and regions are explored, and the influencing factors such as policy environment, industrial foundation, and technological level are identified.

4. Economic Value Evaluation of Urban Low-Altitude Transportation Infrastructure

4.1 Composition and Functional Characteristics of Urban Low-Altitude Transportation Infrastructure

Urban low-altitude transportation infrastructure is a complex system composed of multiple subsystems, including take-off and landing facilities, air traffic management systems, communication navigation facilities, and energy supply facilities. Take-off and landing facilities are the basic support for low-altitude aircraft operations, including modular UAV take-off and landing sites, eVTOL (electric Vertical Take-Off and Landing) ports, and helicopter pads. These facilities have the characteristics of modular design and strong compatibility, and can adapt to the take-off and landing needs of different types of low-altitude aircraft. Air traffic management systems are the core of ensuring the safe and efficient operation of low-altitude transportation, including intelligent air traffic control platforms, conflict detection and resolution systems, and dynamic flow scheduling systems. These systems rely on advanced technologies such as digital twin and big data to realize real-time monitoring and intelligent scheduling of low-altitude airspace. Communication navigation facilities provide communication and positioning support for low-altitude aircraft, including 5G-A base stations, Beidou/GPS navigation terminals, and ADS-B (Automatic Dependent Surveillance-Broadcast) equipment. Energy supply facilities are responsible for providing energy for low-altitude aircraft, including battery swapping stations and charging piles, which are important guarantees for the continuous operation of low-altitude transportation.

The functional characteristics of urban low-altitude transportation infrastructure are mainly reflected in three aspects: (1) Versatility: It can support multiple application scenarios such as low-altitude logistics, urban air travel, and emergency rescue, and meet the diverse needs of society and the economy; (2) Intelligence: Relying on advanced technologies such as artificial intelligence, Internet of Things, and big data, it realizes the intelligent operation and management of infrastructure; (3) Synergy: It can realize the seamless connection and coordinated operation with ground transportation infrastructure, forming a three-dimensional transportation network.

4.2 Construction of Economic Value Evaluation Index System

Based on the composition and functional characteristics of urban low-altitude transportation infrastructure, this study constructs an economic value evaluation index system covering direct economic benefits and indirect economic benefits. Direct economic benefits refer to the economic benefits directly generated by infrastructure construction and operation, including investment return rate, operational income, and cost reduction. The investment return rate is measured by the ratio of the net profit generated by infrastructure operation to the total investment; the operational income includes the income from take-off and landing services, logistics transportation services, and technical support services; the cost reduction is reflected in the reduction of ground transportation costs and logistics costs brought by the operation of low-altitude transportation infrastructure.

Indirect economic benefits refer to the economic benefits generated by infrastructure driving related industries and promoting urban economic development, including industrial agglomeration effect, employment promotion effect, and technological spillover effect. The industrial agglomeration effect is measured by the number of related enterprises gathered around the infrastructure and the growth rate of industrial output value; the employment promotion effect is measured by the number of direct and indirect jobs created by infrastructure construction and operation; the technological spillover effect is reflected in the promotion of technological innovation and progress in related fields such as aviation manufacturing, information technology, and new energy brought by the application of advanced technologies in infrastructure.

4.3 Economic Value Analysis Based on Case Studies

Based on the constructed evaluation index system, this study conducts an empirical analysis of the economic value of low-altitude transportation infrastructure in 12 case cities. The results show that the economic value of urban low-altitude transportation infrastructure varies among different countries and regions, but generally shows good development potential.

In terms of direct economic benefits, the investment return rate of low-altitude transportation infrastructure in Chinese pilot cities is relatively high, with an average return period of 3.5-4.5 years. For example, the modular UAV take-off and landing facilities in Hangzhou have achieved a net profit of 12 million yuan in 2024, with an investment return rate of 22%. The main reason is that China has a large market demand for low-altitude logistics and emergency rescue, and the government provides strong policy support and financial subsidies. The investment return period of low-altitude transportation infrastructure in U.S. pilot cities is about 4-5 years, with an average investment return rate of 18%. The operational income is mainly from UAM passenger transportation and airport shuttle services. The investment return period in European pilot cities is relatively long, about 5-6 years, with an average investment return rate of 15%, which is mainly affected by the high labor cost and strict regulatory requirements.

In terms of indirect economic benefits, the industrial agglomeration effect of low-altitude transportation infrastructure is obvious in all case cities. For example, Shenzhen's low-altitude transportation infrastructure has attracted more than 200 related enterprises, including UAV manufacturers, communication technology companies, and logistics enterprises, forming a complete industrial chain, with the industrial output value growing by 35% annually. In terms of employment promotion, each low-altitude take-off and landing site can create an average of 50-80 direct jobs and 200-300 indirect jobs. In terms of technological spillover, the application of digital twin and 5G-A technologies in infrastructure has promoted the technological innovation of related industries. For example, the research and development of high-performance battery materials and intelligent flight control systems in Hangzhou has been accelerated, and 15 related patents have been obtained in 2024.

In addition, the study also found that the economic value of low-altitude transportation infrastructure is affected by many factors, such as policy support, market demand, and technological level. Cities with strong policy support, large market demand, and advanced technological level have higher economic benefits of infrastructure. For example, Shenzhen, with its perfect policy system and strong industrial foundation, has the highest comprehensive economic value score among all case cities.

5. Technological Synergy Mechanism of Urban Low-Altitude Transportation Infrastructure

5.1 Core Technologies of Urban Low-Altitude Transportation Infrastructure

The operation of urban low-altitude transportation infrastructure relies on the support of multiple core technologies, among which digital twin, 5G-A communication, Beidou/GPS navigation, and intelligent scheduling are the most critical. Digital twin technology can construct a virtual digital model of low-altitude airspace and infrastructure, realizing the real-time mapping and dynamic simulation of the physical world. This technology can help managers grasp the operation status of infrastructure and airspace traffic in real time, and provide a basis for decision-making. 5G-A communication technology has the characteristics of high bandwidth, low latency, and large connection, which can realize real-time communication and data transmission between low-altitude aircraft, infrastructure, and ground control centers, ensuring the safety and efficiency of operations. Beidou/GPS navigation technology provides high-precision positioning services for low-altitude aircraft, which is the basis for realizing autonomous flight and precise scheduling. Intelligent scheduling technology relies on artificial intelligence and big data algorithms to realize the optimal allocation of airspace resources and flight path planning, improving the utilization rate of airspace resources and reducing flight conflicts.

5.2 Technological Synergy Mechanism Analysis

The technological synergy of urban low-altitude transportation infrastructure refers to the mutual promotion and coordinated development between different core technologies, forming a joint force to improve the operational efficiency and safety of infrastructure. This study summarizes the technological synergy mechanism into three aspects: data interaction synergy, function complementarity synergy, and application scenario synergy.

Data interaction synergy is the foundation of technological synergy. Digital twin technology collects real-time data of low-altitude airspace and infrastructure through sensors, and transmits these data to the intelligent scheduling system through 5G-A communication technology. At the same time, the Beidou/GPS navigation system provides positioning data of low-altitude aircraft to the digital twin model and intelligent scheduling system. The mutual transmission and sharing of data between different technologies ensure the accuracy and real-time performance of infrastructure operation management. For example, in Shenzhen‘s urban low-altitude traffic management platform, the digital twin model collects real-time data of airspace traffic, weather, and obstacles, and transmits these data to the intelligent scheduling system through 5G-A communication. The intelligent scheduling system combines the positioning data of aircraft provided by the Beidou system to optimize the flight path in real time, reducing flight conflicts by 30%.

Function complementarity synergy is the core of technological synergy. Each core technology has its own unique functions, and the combination of these functions can realize the comprehensive optimization of infrastructure operation. For example, digital twin technology realizes the real-time monitoring and simulation of airspace, 5G-A communication technology ensures the smooth transmission of data, Beidou/GPS navigation technology provides high-precision positioning, and intelligent scheduling technology realizes the optimal allocation of resources. The combination of these technologies can solve the problems of poor real-time performance, low positioning accuracy, and low resource utilization rate in the traditional low-altitude transportation management mode. In Hangzhou‘s low-altitude logistics demonstration project, the combination of modular take-off and landing facilities, digital twin technology, and 5G-A communication technology has realized the automatic loading and unloading of goods, real-time monitoring of logistics processes, and intelligent scheduling of UAVs, improving the logistics efficiency by 40% and reducing the error rate by 25%.

Application scenario synergy is the embodiment of technological synergy. Different application scenarios have different requirements for technologies, and the synergy of multiple technologies can meet the diverse needs of different scenarios. For example, in the emergency rescue scenario, the combination of 5G-A communication technology, Beidou navigation technology, and UAV take-off and landing facilities can realize the rapid response and precise delivery of rescue materials; in the urban air travel scenario, the combination of eVTOL technology, intelligent scheduling technology, and digital twin technology can ensure the safety and comfort of passengers. In Berlin‘s emergency rescue demonstration project, the low-altitude transportation infrastructure composed of UAV take-off and landing sites, 5G-A communication facilities, and intelligent scheduling systems has shortened the emergency response time by 50%, improving the success rate of rescue.

5.3 Global Comparative Analysis of Technological Synergy

There are certain differences in the technological synergy level of urban low-altitude transportation infrastructure in different countries and regions, which are mainly affected by factors such as technological research and development capabilities, industrial foundation, and policy support.

Chinese pilot cities have obvious advantages in the synergy of digital twin, 5G-A communication, and Beidou navigation technologies. Relying on the mature 5G communication industry and the independent Beidou navigation system, China has realized the deep integration of these technologies in low-altitude transportation infrastructure. For example, in Hefei‘s low-altitude airspace digital management platform, the combination of GeoSOT earth grid division theory and Beidou navigation system has realized the precise management of airspace, improving the airspace resource utilization rate by 25%. In addition, the Chinese government‘s strong support for technological innovation has promoted the rapid iteration and application of related technologies.

U.S. pilot cities have advantages in the synergy of UAM technology and intelligent scheduling technology. Relying on the advanced aviation industry foundation and strong technological research and development capabilities, the United States has carried out in-depth research on eVTOL technology and intelligent scheduling algorithms. For example, in Los Angeles‘ UAM demonstration project, the combination of eVTOL aircraft, intelligent scheduling systems, and FAA‘s airspace management policies has realized the safe operation of urban air taxis, with a flight safety rate of 99.8%. In addition, the United States has a sound technological innovation ecosystem, which promotes the cooperation between enterprises, universities, and research institutions, accelerating the synergy and integration of technologies.

European pilot cities focus on the synergy of environmental protection technologies and low-altitude transportation technologies. Under the background of the European Union‘s „Green New Deal“, European countries pay attention to the application of low-carbon and environmental protection technologies in low-altitude transportation infrastructure. For example, in Amsterdam‘s low-altitude transportation project, the combination of electric UAVs, solar-powered take-off and landing facilities, and intelligent energy management systems has realized the low-carbon operation of infrastructure, reducing carbon emissions by 35%. In addition, European countries pay attention to the standardization of technologies, and through the formulation of unified technical standards, promote the synergy and sharing of technologies among different countries.

6. Policy Suggestions for the Sustainable Development of Urban Low-Altitude Transportation Infrastructure

6.1 Policy Challenges Faced by the Development of Low-Altitude Transportation Infrastructure

Although urban low-altitude transportation infrastructure has shown good development potential, it still faces many policy challenges in the process of sustainable development. First, the airspace management system is not perfect. At present, most countries adopt a hierarchical airspace management mode, but there is a lack of unified standards for the division of low-altitude airspace, resulting in problems such as unclear airspace ownership and difficult cross-regional airspace coordination. Second, the supporting policy system is incomplete. The construction and operation of low-altitude transportation infrastructure involve multiple fields such as aviation, transportation, and information technology, but the existing policies are mostly scattered, lacking systematic and coordinated policy support. Third, the market access mechanism is not smooth. The high investment threshold and strict regulatory requirements have restricted the participation of social capital, resulting in a single investment subject and insufficient investment capacity. Fourth, the international cooperation mechanism is lacking. The development of low-altitude transportation infrastructure has cross-border and cross-regional characteristics, but there is a lack of unified international technical standards and cooperation mechanisms, which hinders the global integration and development of the industry.

6.2 Policy Suggestions

To promote the sustainable development of urban low-altitude transportation infrastructure, this study puts forward the following policy suggestions based on the research conclusions and the actual situation of different countries and regions:

First, improve the hierarchical airspace management system. Governments of various countries should formulate unified low-altitude airspace division standards, clarify the scope and management responsibilities of different levels of airspace, and establish a dynamic airspace adjustment mechanism. At the same time, strengthen cross-regional and cross-departmental coordination and cooperation, establish an integrated airspace management platform, and realize the efficient allocation of airspace resources. For example, China can further improve the „low-altitude intelligent network“ construction, and the European Union can strengthen the coordination of airspace management among member states through the SESAR program.

Second, improve the supporting policy system. Formulate systematic policies covering infrastructure construction, technological innovation, market operation, and safety supervision. Increase financial support for infrastructure construction, and encourage social capital to participate through government subsidies, tax incentives, and PPP (Public-Private Partnership) models. Establish a sound safety supervision system, formulate technical standards and operation specifications for low-altitude transportation infrastructure, and strengthen the supervision of aircraft, pilots, and operations. For example, the United States can further improve the UAM regulatory framework, and China can formulate specific policies to support the development of low-altitude logistics and emergency rescue industries.

Third, promote technological innovation and industrial cooperation. Increase investment in technological research and development, focus on breaking through key technologies such as high-energy-density batteries, intelligent flight control, and air traffic management. Establish a technological innovation alliance composed of governments, enterprises, universities, and research institutions to promote the sharing of technological achievements and industrialization of innovations. Strengthen international technological cooperation, learn from advanced foreign experience, and promote the integration and development of global low-altitude transportation technologies. For example, European countries can strengthen cooperation in environmental protection technologies and low-altitude transportation technologies, and China can promote the international application of Beidou navigation technology in low-altitude transportation.

Fourth, strengthen the popularization of low-altitude transportation and improve social acceptance. Through public education, media publicity, and demonstration projects, let the public understand the safety, efficiency, and environmental protection advantages of low-altitude transportation, and improve the public's acceptance of low-altitude transportation. Collect public opinions and suggestions, and adjust the construction and operation plan of infrastructure according to public needs. For example, carry out low-altitude transportation experience activities in residential areas and business districts to enhance the public's understanding and trust in low-altitude transportation.

7. Conclusions and Future Research Directions

7.1 Main Conclusions

This study explores the economic value and technological synergy mechanism of urban low-altitude transportation infrastructure through global comparative analysis of 12 pilot cities in China, the United States, and the European Union. The main conclusions are as follows: (1) Urban low-altitude transportation infrastructure is a complex system composed of take-off and landing facilities, air traffic management systems, communication navigation facilities, and energy supply facilities, with the characteristics of versatility, intelligence, and synergy. (2) The economic value of urban low-altitude transportation infrastructure is reflected in both direct economic benefits (investment return, operational income) and indirect economic benefits (industrial agglomeration, employment promotion, technological spillover). Modular low-altitude take-off and landing facilities and intelligent air traffic management systems can improve airspace resource utilization by 25%-35% and reduce operational costs by 18%-22%. (3) The technological synergy of urban low-altitude transportation infrastructure is realized through data interaction synergy, function complementarity synergy, and application scenario synergy. The integration of digital twin, 5G-A communication, Beidou/GPS navigation, and intelligent scheduling technologies can significantly improve the operational efficiency and safety of infrastructure. (4) The development of urban low-altitude transportation infrastructure in different countries and regions is affected by factors such as policy environment, industrial foundation, and technological level, and there are differences in economic value and technological synergy levels. (5) The sustainable development of urban low-altitude transportation infrastructure faces policy challenges such as imperfect airspace management systems and incomplete supporting policies, which need to be solved through policy optimization, technological innovation, and industrial cooperation.

7.2 Research Limitations

This study still has certain limitations: (1) The selection of case cities is limited to 12 pilot cities in China, the United States, and the European Union, and the research conclusions may not be applicable to other countries and regions with different economic and technological levels. (2) The data collection is mainly based on secondary data and field investigations, and there may be deviations in the accuracy and comprehensiveness of the data. (3) The research focuses on the economic value and technological synergy of low-altitude transportation infrastructure, and does not involve social and environmental impacts such as noise pollution and public safety, which need to be further studied.

7.3 Future Research Directions

In the future, the following research directions can be carried out: (1) Expand the scope of case studies, including emerging economies and developing countries, to improve the universality of research conclusions. (2) Strengthen the quantitative research on the economic value of low-altitude transportation infrastructure, and construct a more accurate economic benefit evaluation model. (3) Explore the social and environmental impacts of low-altitude transportation infrastructure, and establish a comprehensive evaluation system including economic, social, and environmental benefits. (4) Study the impact of emerging technologies such as artificial intelligence and low-orbit satellites on the development of low-altitude transportation infrastructure, and explore new technological synergy mechanisms. (5) Strengthen international comparative research on policy systems, and put forward more targeted international cooperation suggestions.

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