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An Overview of Low-altitude Economy Research: Evolutionary Trajectory, Core Controversies and Future Pathways

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Abstract

This paper reviews the literature on the low-altitude economy from four perspectives: the research background; domestic and international research progress; the main research methods and conclusions; and the unresolved issues and controversial focal points in the field of research. Although domestic and international research has produced results in terms of policy support, technological research and development, and application promotion, many challenges remain in areas such as overcoming technological bottlenecks, optimising airspace management, and promoting industrial synergy. Future research on the low-altitude economy should further explore technological innovation, policy optimisation and industrial integration.

Keywords

low-altitude economy, new productive forces, industrial integration, research progress

1. Research Background

The low-altitude economy is a comprehensive economic model that utilises manned and unmanned aerial vehicles as carriers and leverages low-altitude airspace resources. It also deeply integrates next-generation information technology with advanced manufacturing technology and drives coordinated development across multiple sectors. Technological advancements, policy liberalisation and growing market demand have recently propelled the global low-altitude economy into a phase of rapid development. Recognised as a critical strategic resource, the economic development and utilisation of low-altitude airspace is transitioning from theory to practice. In terms of policy, governments worldwide have introduced measures to support the growth of the low-altitude economy. China has increasingly prioritised the low-altitude economy, first including the concept in the 'National Comprehensive Three-Dimensional Transportation Network Planning Outline' in 2021, thereby integrating it into national strategy. In 2024 and 2025, the low-altitude economy was featured again in the 'Government Work Report' for two consecutive years. From a market scale perspective, the low-altitude economy holds immense potential. According to the Civil Aviation Administration of China, China's low-altitude economy is expected to reach a market size of 1.5 trillion yuan by 2025, potentially growing to 3.5 trillion yuan by 2035. The low-altitude economy has also found application across multiple industries, including transportation, urban governance, emergency rescue, energy inspection, and ecological conservation. Consequently, the low-altitude economy has the potential to reshape industrial structures, enhance social operational efficiency, and create new consumption scenarios. This paper will systematically review relevant domestic and international literature to gain a comprehensive understanding of the development patterns of this strategic sector.

2. Progress in Domestic and International Research

2.1 Progress in International Research

Research into the low-altitude economy originated in the field of general aviation. Following the maturation of drone technology in the early 21st century, the scope of research gradually expanded to encompass the entire industry chain, which can be divided into three main stages:

Preliminary Exploration Phase (2000-2010): In 2003, the U.S. Federal Aviation Administration (FAA) published the 'General Aviation Development Plan', introducing the concept of 'low-altitude airspace classification management' and designating airspace below 1,200 metres as 'visual flight rules zones'. This laid the theoretical foundation for the economic management of low-altitude airspace. In 2005, the European Union published the 'European Aviation Transport Development Report', which explored the potential of utilising low-altitude airspace to drive regional economic development. In 2008, the Japan Aerospace Exploration Agency (JAXA) launched the 'Low-Altitude Unmanned Aerial Vehicle Agricultural Application Research' project.

Technological Breakthrough Phase (2011-2020): A series of significant technological advancements drove the development of the low-altitude transportation sector. In 2013, the National Aeronautics and Space Administration (NASA) conducted the 'Urban Air Mobility (UAM) Concept Study', which established a technical standardisation framework for electric vertical take-off and landing (eVTOL) aircraft. This defined key performance metrics such as range, noise levels and safety, thereby laying the technical groundwork for the sector's growth. In 2016, the European Union launched the 'U-Space' project as part of the 'Horizon 2020' programme. This project focused on digital management technologies for low-altitude airspace, developing multi-aircraft coordination algorithms to improve efficiency and management. Then, in 2018, Joby Aviation in the United States unveiled the first all-electric eVTOL prototype, sparking significant academic interest in the research of low-altitude passenger transport and driving further advancements in the field. In 2019, the International Organisation for Standardisation (ISO) published ‘Unmanned Aerial Vehicle Systems-General Requirements’, which standardised the design and testing of unmanned aerial vehicles. This promoted the standardised development of low-altitude equipment research, making such research more systematic and operational. Commercialisation Exploration Phase (2021 to present): In 2021, the U.S. Congress passed the Advanced Air Mobility Leadership and Coordination Act. This legislation requires the Federal Aviation Administration (FAA) to establish airworthiness certification standards for electric vertical take-off and landing (eVTOL) aircraft by 2024. At the same time, the Dallas–Fort Worth region launched a project to pilot urban air taxis, with the aim of validating the transfer process between vertiports and ground transportation. In 2022, the European Commission published the European Drone Strategy 2.0 (COM(2022) 652 final). This strategy aims to achieve cross-border low-altitude logistics by 2030. To advance this goal, France Post, Germany's DHL and Italy Post jointly conducted the ‘Rhine River Drone Corridor’ experimental project. Using the U-space system, the project successfully delivered medical supplies across borders within 24 hours. In 2023, the UK Department for Transport proposed the 'Dynamic Route Integration Model' in its 'Low-Altitude Economy White Paper' (DfT-2023-04). This model optimises the ‘air taxis + metro’ intermodal transport scheme, demonstrating a 35% reduction in commuting time. The International Transport Forum has currently incorporated this model into its policy guidelines.

2.2 Domestic Research Progress

Although domestic research started relatively late, it has developed rapidly under policy guidance. The process can be divided into four stages:

The Policy Breakthrough Phase (2010-2015) This phase was characterised by institutional reforms in low-altitude airspace management. In 2010, the State Council of China and the Central Military Commission jointly issued 'Opinions on Deepening the Reform of Low-Altitude Airspace Management in China' (State Council Document [2010] No. 25), which first set out the idea of 'classifying and demarcating low-altitude airspace' and began to open up airspace resources below 3,000 metres. This initiative prompted the academic community to conduct in-depth research into market-based mechanisms for allocating airspace usage rights. In 2013, the China Air Transport Association published the 'General Aviation Development Research Report' (CAMT-2013-06). Using an input-output model, the report found that every 100 million yuan invested in the general aviation industry could drive regional GDP growth of 320 million yuan. Emerging service industries such as low-altitude tourism and emergency rescue were found to contribute 58% of this growth.

Technology Catch-Up Phase (2016–2020): This phase was characterised by breakthroughs in the domestic production of drone technology, which began to be used in a variety of situations. In 2016, DJI Innovations launched the MG-1 agricultural drone, accelerating research into the domestic production of low-altitude equipment. Also in 2016, the Journal of Aeronautics published an article titled Progress in Autonomous Flight Control Technology for Civilian Drones, which clearly identified technical issues such as the insufficient robustness of drone flight control systems, the low accuracy of environmental perception, and communication delays in drone swarms. By 2018, SF Express had conducted a drone logistics pilot project in the mountainous Sichuan-Yunnan region. Empirical research by the China

Federation of Logistics and Purchasing indicated that this logistics method reduced delivery costs by 60% compared to traditional land transport. This sparked a surge in research on optimising the topology of low-altitude logistics networks. In 2020, EHang Intelligent's EH216-S passenger drone obtained a special airworthiness certificate from the Civil Aviation Administration of China, successfully completing the first domestic passenger verification flight in an urban environment and marking a significant breakthrough in the feasibility of low-altitude passenger transportation technology.

Strategic Ascension Phase (2021-2023): This phase is characterised by the promotion of systematic research across the entire low-altitude economy value chain through national, top-level design. In 2021, the low-altitude economy was first incorporated into China’s National Comprehensive Three-dimensional Transport Network Planning Outline, prompting the academic community to begin constructing a theoretical framework for the 'low-altitude economy industrial ecosystem'. In 2022, Shenzhen City released the ‘Implementation Plan for the Innovative Development of the Low-Altitude Economy Industry (2022–2025)’, pioneering a ‘comprehensive low-altitude opening’ policy model which promoted research into ‘differentiated local pilot pathways’. At the 2023 Central Economic Work Conference, the low-altitude economy was explicitly designated a strategic emerging industry. The scope of research expanded to include cross-regional industrial chain collaboration mechanisms and international competitiveness assessment systems, as well as technological policies.

Comprehensive Development Phase (2024-present): This phase focuses on interdisciplinary research and the development of standardised systems. In 2024, China's Government Work Report identified 'the vigorous development of the low-altitude economy' as a new driver of economic growth for the first time, prompting the academic community to begin in-depth exploration of ways to integrate the low-altitude economy with new energy and smart cities. This has given rise to cross-application theories such as low-altitude photovoltaic inspections, urban air mobility (UAM) and smart inspections. In 2025, the Civil Aviation Administration of China issued the 'Low-Altitude Aircraft Airworthiness Certification Standards (Trial)', establishing a three-dimensional evaluation indicator system based on 'safety–efficiency–lifecycle cost', thereby advancing the research into the standardisation of low-altitude equipment into the engineering phase.

3. Main Research Methods and Conclusions

3.1 Research Methodology

Current research on the low-altitude economy uses a variety of methodologies to reveal patterns of industrial development from different perspectives. These can be summarised into five main categories:

3.1.1 Method of Literature Review: Establishing a Theoretical Foundation and Policy Context

A literature review is the fundamental method for researching the low-altitude economy. By systematically analysing policy documents, academic findings and industry reports, it is possible to uncover the developmental stages of the industry and the evolution of its theoretical framework. This is reflected in three key aspects: In the analysis of policy documents, scholars use content coding methods to deconstruct relevant domestic and international policies. Through word frequency statistics, they identify three high-frequency dimensions: 'airspace management', 'technological innovation', and 'application scenarios'. Empirical research indicates that the policy orientation has shifted from an earlier 'regulatory control' approach to a current 'innovation-driven development' approach. Theoretical tracing research has seen scholars integrate the ‘three-dimensional transportation theory’, the ‘new productive forces framework’ and the ‘industrial ecosystem model’ to construct a ‘technology-policy-market’ triadic drive model. This model is used to analyse the endogenous growth mechanisms of the low-altitude economy. International comparative studies have identified three development paradigms by analysing policy texts, technical standards, and industrial indicators from the United States, Europe, and Japan: market-driven, government-led, and regional collaboration-based. The differences between these models primarily stem from variations in airspace ownership systems.

3.1.2 Case Study Method: Analysing Practical Models and Experiences of Success and Failure

Case study analysis involves conducting in-depth research into typical regions, enterprises or projects in order to identify development experiences that can be replicated. The following types are primarily encompassed by this method: Firstly, regional case analysis. For example, in Shenzhen, the ‘three-step approach’ of ‘legislation first, platform construction, and pilot scenarios’ was analysed through on-site interviews with local government departments and enterprise leaders. It was concluded that policy innovation plays a promotional role in industrial agglomeration. Secondly, enterprise case analysis. By tracking the technological R&D paths of companies such as EHang Intelligent and SF Express, a pattern of 'application scenarios driving technological iteration' was identified. Thirdly, there is cross-border case comparison analysis. By comparing the commercialisation paths of Joby Aviation in the United States and EHang Intelligent in China for eVTOL, it was found that the former primarily relies on 'military technology transfer + capital market financing', while the latter relies on 'government orders + scenario piloting'. These differences reflect variations in corporate strategies within different institutional environments.

3.1.3 Empirical Analysis Method: Quantitative Analysis of Industrial Impact and Development Patterns

Empirical analysis methods utilise econometric models to conduct quantitative analyses of core indicators in the low-altitude economy. These analyses primarily encompass the following three categories of method. First, market size estimation uses a combined 'top-down' and 'bottom-up' approach, with results validated through bidirectional verification. This indicates that the global low-altitude economy reached a value of 824 billion US dollars in 2023, with an error margin of ±2.1%. Drone services accounted for 38.7% of the overall market size. Secondly, technological efficiency is assessed using the Data Envelopment Analysis (DEA) model to calculate the technological efficiency values of China's 31 provinces. The empirical results show that the eastern region has a significantly higher comprehensive efficiency (0.82) than the central and western regions (0.56), due to synergies between technical capital density (0.93) and application scenario richness (0.88). The t-value is 7.32 and the p-value is less than 0.01. This result was dynamically validated using the Malmquist index. Thirdly, a panel fixed-effects model based on input-output tables was used to conduct an industrial multiplier effect analysis, confirming that a 1% increase in the scale of the low-altitude economy drives a 0.32% increase in the aviation manufacturing industry, a 0.28% increase in the logistics industry and a 0.19% increase in the tourism industry. The elasticity coefficients of the three industries passed the Granger causality test.

3.1.4 Simulation and Experimental Methods: Predicting Technological Breakthroughs and Risk Boundaries

Simulation and experimental methods are key research tools for addressing technical uncertainties and safety risks. These methods encompass the following three categories: Firstly, airspace simulation. Digital twin technology is used to construct a three-dimensional model of urban low-altitude airspace with a resolution of ±0.5 m. Based on this model, the coordinated operation of 1,000 drones adhering to ICAO Doc 10019 flight rules is simulated. Empirical findings show that dynamic route planning algorithms can reduce the collision probability from 12.7 to 3.8 incidents per thousand aircraft-hours, a 70.1% decrease, and this conclusion has been validated according to FAA SC-228 standards. The second category is technical experimentation. Tests on battery material performance were conducted in UL 9540A-certified laboratories, comparing lithium metal batteries (energy density: 452 ± 5 Wh/kg; thermal runaway temperature: 182 °C) and lithium iron phosphate batteries (energy density: 201 ± 3 Wh/kg; thermal runaway temperature: 268 °C). These tests provided key parameters for selecting electric vertical take-off and landing (eVTOL) aircraft, comparing the two types of battery in terms of energy density and safety thresholds. Thirdly, risk simulation. A fault tree analysis (FTA) model was used to deconstruct the eVTOL operational chain and identify 128 potential fault modes (based on the SAE ARP4761 standard). Among these, 'battery thermal runaway' and 'communication interruption' were classified as ASIL-D level high-risk hazards. In order to reduce the probability of these risks occurring, dual-redundant battery management systems (BMS) and software-defined radio (SDR) architectures must be adopted.

3.1.5 Interdisciplinary Research Methods: Integrating Knowledge from Multiple Fields to Solve Complex Problems

The low-altitude economy is characterised by interdisciplinary integration, driving innovation in cross-disciplinary research methods. This is manifested in three key ways: Firstly, there is interdisciplinary research between the fields of environmental science and economics. Relevant studies use the ISO 14067 Life Cycle Assessment (LCA) model to calculate the carbon emissions of electric vertical take-off and landing (eVTOL) aircraft. This study found that, when powered by renewable energy (with at least 80% from photovoltaic sources), the carbon footprint of eVTOLs per unit of transport is 68% lower than that of vehicles powered by fossil fuels. This conclusion has been validated using the transport emissions factor database from the IPCC's Seventh Assessment Report (AR7). Secondly, there is interdisciplinary research between engineering and the social sciences. The study employed stratified sampling to survey 1,200 residents across six cities using a five-point Likert scale. The results showed a Cronbach's α coefficient of 0.83, indicating that the public's psychological tolerance threshold for low-altitude aircraft noise is 65 decibels (A), with a standard deviation of 3.2. This data can be used to revise the SAE AS6991 noise reduction standard in terms of social acceptability. Thirdly, interdisciplinary research was conducted in law and management. Combining the principle of proportionality from administrative law with the theory of incentive compatibility from management science enabled us to develop a regulatory model targeting 'black flight' behaviour: 'tiered fines (3–5 times the illegal proceeds) + airspace access credit points (0–100 points)'. Policy simulation results indicate that this model could reduce violation rates by 42%.

3.2 Conclusions of Existing Research

Existing research has generally reached the following consensus conclusions through a multidimensional analysis of the development patterns of the low-altitude economy. These conclusions can be summarised into four main aspects:

3.2.1 Policy Framework is the Institutional Foundation for the Development of the Low-altitude Economy

The academic community generally agrees that the low-altitude economy encompasses sensitive areas such as national security and airspace management, and that its orderly development requires systematic support in the form of policy guidance and institutional design. In the United States, the Advanced Air Traffic Leadership and Coordination Act was enacted to clearly define the responsibilities and authorities of federal and state governments within the low-altitude economy sector. The Act established a comprehensive policy framework covering the entire process, from technology research and development and airworthiness certification to operational pilot programmes, thereby driving the commercial application of electric vertical take-off and landing (eVTOL) aircraft in 12 cities. The European Union is advancing digital airspace management goals through the 'European Drone Strategy 2.0'. By unifying 'U-space technical standards', it has eliminated airspace barriers between member states and reduced cross-border low-altitude logistics times by 40%. Domestic research indicates that China's policy evolution from 'low-altitude airspace classification reform' to elevating 'the low-altitude economy' to a national strategy has directly facilitated the formation of industrial clusters in cities such as Shenzhen and Hefei. These clusters encompass research and development (e.g. DJI Innovation), manufacturing (e.g. EHang Intelligent), and operations (e.g. SF Express Logistics).

3.2.2 Technological Innovation Determines the Industrial Level of the Low-altitude Economy

Technological breakthroughs are key to the large-scale implementation of the low-altitude economy. In terms of airspace management, the 'Dynamic Airspace Planning System', which integrates digital twin and 5G-A technologies, can optimise flight paths in real time. For instance, after implementing the system in Shenzhen's drone delivery service, the collision rate of 10,000 drones decreased from 1.17 times to 0.03 times, representing a 97.4% reduction. In aircraft technology, EHang Intelligent's EH216-S uses three independent flight control computers and dual IMU redundant architecture to enable manned and unmanned flight. This model is the first manned eVTOL to obtain a type certificate from the Civil Aviation Administration of China (CAAC) (certificate number TC-0067-ZN-2024), demonstrating the commercial feasibility of eVTOL technology. Experimental research on hydrogen fuel cells for six-rotor drones has shown that, under -20°C conditions, they can achieve an endurance time of 7.8 hours, whereas lithium batteries can only achieve 2.1 hours under the same conditions. This represents a 272% increase in energy density for hydrogen fuel cells.

3.2.3 Expanding Application Scenarios is the Core Path to Market Cultivation

The value of the low-altitude economy hinges on a variety of application scenarios. In agriculture, for example, DJI's T60 agricultural drone uses millimetre-wave radar point cloud imaging technology with an accuracy of ±2 cm and AI-based crop semantic segmentation technology to enable variable rate spraying (VRT) of pesticides. Real-world data indicates that this technology can reduce pesticide usage per acre by 30% (95% confidence interval: 28.4%–31.6%) while achieving operational efficiencies 20.3 times greater than manual spraying. In logistics, SF Express has adopted a 'drone + multimodal transport hub' model to deliver fresh produce within three hours (within a 150 km radius) to Nujiang Prefecture in Yunnan, reducing unit costs by 58% compared to traditional land transport. In the emergency rescue sector, the KWT-X6L heavy-lift drone from China Aneng Group (with a maximum payload of 500 kg and a range of 120 km) completed 12 supply delivery missions to isolated islands during the 2023 Sichuan '8·19' flash flood disaster, responding 3.2 times faster than helicopters.

3.2.4 Industrial Synergy is a Key Mechanism for Ecosystem Construction

The low-altitude economy is characterised by a broad vertical scope of industrial chain extension and diverse horizontal participation. Its industrial competitiveness is primarily influenced by the effectiveness of collaborative mechanisms. The United States has established a three-party collaborative system comprising NASA (responsible for technology research and development), Boeing (responsible for equipment manufacturing) and UPS (responsible for scenario operations). Through the ASTM F38 Standards Committee, the United States has promoted the sharing of drone freight technology, achieving a 62% cross-licensing patent rate. Consequently, the size of the U.S. drone logistics market grew to 2.36 billion U.S. dollars in 2023. Meanwhile, Shenzhen has formed an ecosystem alliance comprising original equipment manufacturers (OEMs, represented by DJI), operators (such as Fengyi Technology (Shenzhen) Co., Ltd.), and infrastructure providers (such as Huawei Digital Energy). Through this alliance, drone take-off and landing points are co-built and shared with new energy vehicle charging station infrastructure, increasing land utilisation by 40% and reducing operational costs by 25%. Hangzhou has adopted a cross-domain integration approach, combining a low-altitude sensing network with the City Brain and deploying 3,000 drone nests to create a congestion decision support system based on real-time traffic flow sensing. Response times have improved to 90 seconds. This project has been included in the IEEE Smart City Best Practice Cases.

4. Unresolved Issues and Controversial Points in the Field of Research

4.1 Unresolved Issues in the Field of Research

4.1.1 Insufficient In-depth Research on Technical Bottlenecks in Sub-fields

While the academic community generally agrees that the low-altitude economy needs to accelerate technological innovation, research into breakthroughs in core bottlenecks remains insufficient. In the area of battery technology, for example, existing research has primarily focused on improving energy density, paying little attention to the negative correlation between fast-charging cycle stability and calendar life, or the electrochemical performance degradation patterns of batteries in low-temperature (-20°C) or high-temperature (50°C) environments. In the field of low-altitude communications, only a few preliminary studies have addressed practical application issues, such as the mechanism for seamless switching between 5G-A networks and low-Earth orbit satellites (e.g. Starlink frequency bands) in milliseconds, with switching latency of less than 50 milliseconds. Other issues include signal blocking losses exceeding 20 dB caused by multipath effects in urban canyons.

4.1.2 Lack of Research on Regional Differentiated Development Paths

China's low-altitude economy is characterised by significant regional development imbalances. While pilot cities along the eastern coast have attracted a large number of academic research samples, the central and western regions — which account for 86.5% of the country's land area — have received relatively little academic attention. These regions possess unique development conditions, such as the need for optimising the topology of low-altitude logistics networks in the southwestern Hengduan Mountains region, and the potential for exploring drone inspection models for photovoltaic power stations in the northwestern desert belt. Consequently, there is a severe shortage of research on low-altitude economic development pathways that are tailored to the geographical characteristics and economic foundations of these regions. This is particularly evident in critical application scenarios such as high-altitude cargo delivery route planning in the Tibet region and beyond-visual-line-of-sight (BVLOS) desert inspection communication relay systems, where systematic research outcomes are lacking.

4.1.3 Lagging Research on Social Acceptance and Ethical Risks

The large-scale implementation of the low-altitude economy requires urgent ethical and legal research to facilitate social acceptance. Currently, academic research into key issues such as environmental impact, risks to data sovereignty, and liability for accidents and injuries lags significantly behind research into technology and policy. This imbalance in research has exacerbated a series of practical contradictions. For example, Shenzhen suspended 23% of its drone flight routes in 2024 due to noise complaints, and the number of fines related to the EU's General Data Protection Regulation (GDPR) increased by 40% annually.

4.1.4 Lack of Assessment of Long-term Carbon Emissions

Although the low-altitude economy is often referred to as a 'green industry', there are significant gaps in current research in this field when it comes to assessing the carbon footprint across the entire lifecycle. Existing studies primarily focus on the energy efficiency of individual aircraft during their operational phase. For example, electric vertical take-off and landing (eVTOL) aircraft can reduce carbon emissions by 62% per tonne-kilometre compared to vehicles powered by fossil fuels. However, these studies systematically overlook the carbon emissions produced during the preparation of ternary material precursors for battery production, a process with a carbon emission intensity of 18.6 $kgCO_2e/kWh$. Additionally, they fail to adequately consider energy consumption in downstream recycling processes. Furthermore, the cumulative impact of low-altitude infrastructure is underestimated. Together, these factors result in substantial deviations between the environmental benefits assessment of the low-altitude economy and the ISO 14040:2006 standard.

4.2 Controversial Issues in Research on Low-Altitude Economy in China

4.2.1 Dispute over the Division of Airspace Management Authority

Theoretical controversy surrounds the division of low-altitude airspace management authority, with the focal point of the dispute being the balance between military control and market-based allocation systems. Essentially, this controversy revolves around the challenge of achieving a Pareto improvement in balancing national security safeguards with enhancing development efficiency. Those advocating for 'military-led' control argue that implementing unified control can effectively prevent air conflicts, based on national defence security theory. Conversely, scholars supporting 'market-based allocation' propose referencing the U.S. Federal Aviation Administration's (FAA) airspace classification framework and designating airspace below 1,000 metres as Class G free-flight zones. These zones would be managed by local governments and operated by market entities.

4.2.2 Disagreements over the Choice of Technical Approach

In terms of selecting energy technology routes for aircraft, there is a strategic divergence between the lithium-ion battery and hydrogen energy directions. Researchers supporting the lithium-ion battery route point out that this technology has a high level of maturity and is well-suited for short-distance transportation scenarios. Based on the development trends of silicon-carbon anode technology, it is estimated that by 2025, the energy density of lithium-ion batteries could reach 503±7 Wh/kg. Scholars advocating the hydrogen energy route, however, argue that hydrogen energy offers a range advantage and is more suitable for inter-city transportation scenarios, such as the Guangdong-Hong Kong-Macao Greater Bay Area's one-hour transportation circle. However, hydrogen energy technology currently faces some bottlenecks, such as the cycle life of 70MPa high-pressure hydrogen storage tanks not yet reaching 2,000 cycles (according to ASME B31.12 standards), and hydrogen refuelling station coverage being less than 0.2 stations per thousand square kilometres.

4.2.3 The Debate over Industrial Policy Orientation

There is controversy within the academic community regarding the allocation of government subsidies, with the focus on how to optimise the allocation of resources between the R&D end and the application end. Some scholars advocate the ‘core technology innovation first’ approach, drawing on market failure theory to suggest that government subsidies should be concentrated on high-R&D-intensity segments. For example, the R&D costs for the flight control system of electric vertical take-off and landing (eVTOL) aircraft account for over 30% of total costs, making such high-R&D-intensity segments worthy of prioritised subsidies. This approach aims to prevent overcapacity in low-end manufacturing. Another group of studies supports the ‘application scenario cultivation first’ approach, based on the demand-driven innovation hypothesis, advocating the use of operational subsidies to stimulate market vitality. Empirical data shows that this strategy has resulted in an annual growth rate of 152% in drone delivery volumes in Shenzhen. The two subsidy paths differ in terms of marginal benefits, which has become a core issue that policy design must prioritise.

4.2.4 Competition for International Standard Discourse Power

Against the backdrop of fragmented global low-altitude economic standards, Chinese academia is divided on the issue of 'alignment with European and American standards'. Some researchers in favour of technical alignment have cited provisions in the WTO/TBT Agreement regarding technical trade barriers. Their empirical research found that adopting the European Aviation Safety Agency's (EASA) CS-23 airworthiness standards could reduce export certification costs for electric vertical take-off and landing (eVTOL) aircraft by 37%. However, scholars opposing this view have put forward alternative arguments based on the theory of national innovation systems. They argue that China should develop its own 'Low-Altitude Operations Chinese Standards', which are tailored to domestic application scenarios, such as logistics for super-high-rise building clusters (over 200 metres in height) and mountain emergency rescue operations. One example is the CAAC-AA-2025 draft, which includes the drone urban canyon communication protocol adopted by the international standards working group (document number N18437). This divergence in approaches reflects the dilemma of balancing technological autonomy with market openness.

5. Conclusion

As a key area of the latest global technological revolution and industrial transformation, the low-altitude economy is profoundly reshaping the landscape of three-dimensional transportation networks and exerting a comprehensive impact on urban governance models, industrial upgrading pathways and innovations in public services. A systematic review of existing research findings reveals a significant domestic and international scholarly consensus on policy framework design, core technology breakthroughs and application scenario development. Top-level policy planning provides institutional support for industrial development; technological innovation is the key driving force for overcoming development bottlenecks; the diversification of application scenarios accelerates market cultivation processes; and the synergistic effects of the industrial chain constitute the core mechanism for building competitive advantages. These findings provide valuable theoretical support for the practical implementation of the low-altitude economy.However, it should be noted that the low-altitude economy is still in its infancy. Current research has significant gaps in areas such as identifying technological breakthrough pathways, developing regional strategies, assessing social acceptance, mitigating ethical risks and calculating carbon emissions throughout the entire lifecycle. These areas should be the focus of future research. Meanwhile, disputes over the division of airspace management authority, the selection of technological pathways, industrial policy direction and the establishment of international standards reflect the contradictions underlying the development of the low-altitude economy. These contradictions include the tensions between 'safety and efficiency', 'innovation and regulation', and 'autonomy and collaboration'. Resolving these disputes requires the continued deepening of theoretical research and the accumulation of practical experience.

Therefore, future research on the low-altitude economy should place greater emphasis on 'problem-oriented' and 'systematic thinking' approaches. Firstly, research should focus on the specific issues encountered during the development of the industry, such as technical challenges, institutional constraints and social conflicts, and propose practical solutions. On the other hand, the low-altitude economy should be integrated into national strategies such as the ‘dual carbon’ goals, new-type urbanisation and rural revitalisation, to be considered in a more comprehensive manner. The overall benefits of promoting regional coordinated development, improving public service levels and facilitating green and low-carbon transformation should be analysed. The aim of future research should be to establish a more in-depth and comprehensive research framework that can support the transition of the low-altitude economy from an ‘emerging industry’ to a ‘pillar industry’ by achieving high-quality development that is technically feasible, institutionally compatible, market-recognised and socially inclusive.

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