Can the Low-Altitude Economy Enhance Urban Ecological Resilience?

Haoze Hu[1], Ming Lin[2,*], Wenxia Liu[3], Xuanru Yu[3], Qixian Lan[3], Jiaye Xu[3], and Hangyu Shen[3]

[1]Fujian Business University, Fuzhou, Fujian, China
[2]College of International Business and Economics, Fujian Business University, Fuzhou, Fujian, China
[3]Fuzhou Melbourne Polytechnic, Fuzhou, Fujian, China
*linminglh@qq.com

Abstract. The low-altitude economy has emerged as an important manifestation of new quality productive forces. This paper exploits the designation of 26 National Comprehensive Demonstration Zones for the General Aviation Industry in 2017 as a quasi-natural experiment. Annual observations for 289 Chinese cities between 2005 and 2023 are used to estimate the policy effect through a difference-in-differences framework. The preferred specification yields a positive coefficient of 0.0281, significant at the 1% level, indicating that the pilot program increases urban ecological resilience. Further analysis identifies digital infrastructure as an important transmission channel. The regional estimates reveal a pronounced spatial imbalance: the effect is strongest in northeastern and eastern China, modest in central China, and statistically indistinguishable from zero in western China. This pattern suggests that local digital capacity, industrial foundations, and governance conditions may influence the extent to which cities benefit from the policy. By linking low-altitude economic development to ecological resilience, this study extends the literature on the environmental implications of emerging industries and offers evidence for coordinating low-altitude initiatives with digital infrastructure investment and ecological governance.

Keywords: Low-altitude Economy, Urban Ecological Resilience, Digital Infrastructure.

1 Introduction

The low-altitude economy encompasses economic activities centered on the operation of crewed and uncrewed aircraft, together with the industries and services connected to such operations [1, 2]. China began reforming its low-altitude airspace management system in 2010, gradually adjusting airspace classification, operational management, and supporting services to accommodate the expansion of general aviation [3]. A further policy initiative followed in January 2017, when the National Development and Reform Commission released the Implementation Opinions on the Construction of Comprehensive Demonstration Zones for the General Aviation Industry. Under this

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initiative, 26 cities with established industrial foundations and suitable conditions for reform were selected as the first group of demonstration zones [4, 5]. The low-altitude economy subsequently appeared in the 2024 Report on the Work of the Government, where it was identified as an emerging source of economic growth. Its inclusion in the report also underscored its role in cultivating new quality productive forces [6, 7].

Urban ecological resilience (UER) describes the ability of an urban ecosystem to preserve its essential structures and functions when confronted with natural disasters, environmental pollution, resource constraints, and other external disturbances. It also encompasses the capacity to recover, adapt, and reorganize in ways that support long-term sustainable development [8, 9]. The expansion of the low-altitude economy offers new technological and organizational tools for strengthening these capabilities. First, aerial environmental inspection and low-altitude sensing networks enable cities to identify forest fires, floods, and pollutant emissions more accurately and efficiently, thereby improving environmental risk monitoring and early warning [11,12].

This study treats the establishment of the first batch of 26 National Comprehensive Demonstration Zones for the General Aviation Industry in 2017 as an exogenous policy shock. Using city-level panel data, it estimates how the expansion of the low-altitude economy affects urban ecological resilience and to investigate the channel underlying this relationship. The empirical evidence suggests that cities included in the pilot program experienced a significant improvement in ecological resilience.

2 Research Hypotheses

As an emerging component of new quality productive forces, the low-altitude economy connects digital innovation with urban public governance [7]. One important contribution lies in improving cities' ability to withstand ecological risks. Conventional environmental monitoring depends heavily on fixed stations and is therefore constrained in terms of geographical coverage and spatial resolution. Unmanned aerial vehicles, by contrast, can collect high-resolution information across a wide area owing to their mobility and operational flexibility [13]. Drone-supported Earth observation has already been applied to disaster warning and post-disaster environmental assessment [14]. Previous evidence also indicates that drones shorten the time needed to obtain disaster-related information and support faster rescue decisions [10]. These capabilities enable cities to identify environmental threats earlier and respond more efficiently when ecological disturbances occur. The first hypothesis is therefore formulated as follows:

H1: Expansion of the low-altitude economy leads to higher urban ecological resilience.

Digital infrastructure enables the generation, transmission, processing, and storage of information. Unlike conventional physical facilities, it allows data to circulate more efficiently across administrative boundaries and geographical areas, thereby reducing barriers to interdepartmental coordination. Digital infrastructure and the low-altitude economy are closely complementary because low-altitude operations depend on communication networks, sensing systems, and data-processing platforms. Empirical research has found that improvements in digital infrastructure support the high-quality

development of the low-altitude economy [15]. Evidence from the "Broadband China" program further shows that expanded digital infrastructure increases urban ecological resilience [16]. A study of cities in the Pearl River Delta similarly identifies digital infrastructure and digital industrialization as major channels through which the digital economy strengthens ecological resilience [17].

The development of demonstration zones may encourage cities to expand and upgrade the digital facilities required for low-altitude activities. Better digital connectivity can subsequently reduce information frictions and coordination costs in ecological governance, allowing cities to respond more effectively to environmental shocks. On this basis, the second hypothesis is stated as follows:

H2: The low-altitude economy strengthens urban ecological resilience by facilitating the development of digital infrastructure.

3 Methodology

The empirical sample covers 289 Chinese cities over the period from 2005 to 2023. Urban ecological resilience (UER), whose spatial distribution is presented in Figure 1, serves as the outcome variable. Following the measurement frameworks developed by Chu et al. [22] and Guo and Liu [19], the UER index comprises three components: state resilience, pressure resilience, and response resilience. Together, these components provide a comprehensive measure of a city's capacity to maintain ecological stability, withstand environmental pressures, and respond to ecological disturbances.

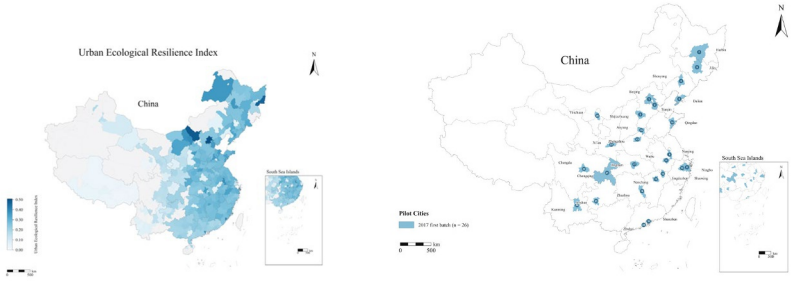


Fig. 1. Urban Ecological Resilience Index (UER)& Pilot Cities in China

This study treats the policy on Comprehensive Demonstration Zones for the General Aviation Industry as an exogenous policy shock. To mitigate potential omitted-variable bias and accurately identify the effect of the low-altitude economy policy on urban ecological resilience, this study selects control variables from five dimensions: GDP Growth (GDPG); Financial Development (FIN); Urbanization Rate (URB); Secondary Industry Share (SEC); Internet Penetration (INT) [18,19,20].

Under the parallel trends, the following DID model is specified:

$$UER_{it} = \alpha_0 + \alpha_1 DID_{it} + \sum_{k=1}^{5} \beta_k Control_{kit} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where UER_{it} denotes the level of ecological resilience of city i. DID_{it} is the difference-in-differences term for the low-altitude economy policy. $Control_{kit}$ denotes the set of control variables.

4 Empirical Analysis

Table 1 presents the baseline estimates. Both model specifications absorb city and year fixed effects, and statistical inference is based on standard errors clustered by city. Without additional covariates, the DID estimate in Column (1) is 0.0580 and significant at the 1% level. After the five control variables are introduced in Column (2), the coefficient falls to 0.0281 but retains the same level of statistical significance. The persistently positive estimate indicates that the pilot program improves urban ecological resilience, thereby providing empirical support for Hypothesis 1.

Table 1. Baseline Estimates

	(1) Urban Ecological Resilience	(2) Urban Ecological Resilience
DID	0.0580***	0.0281***
	(0.0158)	(0.0058)
_cons	0.2044***	0.0856***
	(0.0048)	(0.0106)
Controls	No	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
N	4430	4430
R^2	0.3770	0.3905

Table 2. Results of the Temporal Counterfactual Tests

	(1) 1 Year Earlier	(2) 2 Years Earlier	(3) 3 Years Earlier
DID	0.0079	0.0072	0.0073
	(0.0058)	(0.0060)	(0.0060)
_cons	0.1868***	0.1869***	0.1867***
	(0.0078)	(0.0078)	(0.0078)
Controls	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	4430	4430	4430

4.1 Robustness Tests

1. Parallel Trends Test

Prior to the implementation of the policy in 2017, the urban ecological resilience indices of both the treatment and control groups remained relatively stable [21]. Following the policy launch in 2017, urban ecological resilience in the pilot cities exhibited a clear upward trend (see Figure 2). This post-treatment change provides preliminary evidence that the development of the low-altitude economy contributes to stronger urban ecological resilience.

2. Placebo Test

A placebo exercise is conducted to assess whether the baseline finding could have arisen from chance. Specifically, the model is re-estimated 500 times using randomly generated pseudo-policy indicators. Figure 3 shows that the coefficient obtained from the actual policy setting lies well outside the distribution of the simulated estimates. The baseline result is therefore unlikely to be explained by coincidental sample patterns, lending further credibility to the identified policy effect.

3. Counterfactual Test

A temporal falsification test is also performed by advancing the assumed policy starting year to 2016, 2015, and 2014. If the improvement in urban ecological resilience reflected a pre-existing trend rather than the pilot program, a significant effect would also be expected under these artificial implementation dates. However, although the corresponding estimates remain positive, none reaches conventional levels of statistical significance. The absence of a detectable effect before the actual policy launch provides additional support for the baseline findings (see Table 2).

4.2 Mechanism Analysis

Table 3 examines whether digital infrastructure serves as a channel through which the pilot policy affects urban ecological resilience. Column (1) reports the baseline policy effect: the DID coefficient is 0.0281 and significant at the 1% level. In Column (2), the digital infrastructure index replaces urban ecological resilience as the outcome variable. The resulting DID estimate is 0.0153, which is also significant at the 1% level, suggesting that the pilot program facilitates the expansion of urban digital infrastructure. Column (3) then introduces the digital infrastructure index into the resilience equation. Its coefficient is 0.9198 and remains significant at the 1% level. Taken together, these findings are consistent with the mechanism proposed in Hypothesis 2.

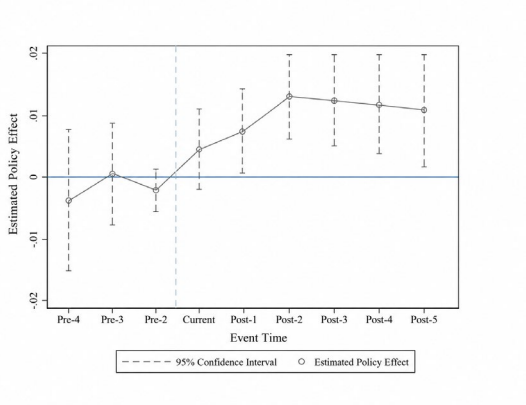


Fig. 2. Results of the Parallel Trends Test

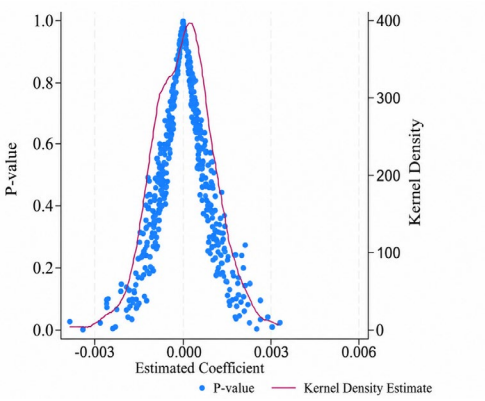


Fig. 3. Results of the Placebo Test

4.3 Heterogeneity Analysis

To examine whether the policy effect varies across different parts of China, the full sample is divided into four geographical groups: eastern, central, western, and northeastern China. The results reveal considerable regional variation. The strongest improvement in urban ecological resilience is observed in northeastern China, where the coefficient reaches 0.0612 and is significant at the 5% level (see in Table 4). A positive effect is also found in eastern China, with a coefficient of 0.0370 that passes the 1% significance test. For central China, the coefficient is 0.0170 and is significant only at the 10% level, indicating a relatively modest policy effect. By contrast, the coefficient for western China is negative at −0.0146 but is not statistically different from zero. Overall, the resilience-enhancing effect of the pilot policy is concentrated primarily in northeastern and eastern China, remains limited in central China, and is not supported by statistically significant evidence in western China.

Table 3. Mechanism Analysis of Digital Infrastructure

	(1) Urban Ecological Resilience	(1) Digital Infrastructure Index	(1) Urban Ecological Resilience
DID	0.0281***	0.0153***	0.0140**
	(0.0058)	(0.0015)	(0.0057)
			0.1958***
			(0.0573)
_cons	0.0856***	-0.0273***	0.1107***
	(0.0106)	(0.0027)	(0.0104)
N	4430	4430	4430
Controls	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
R^2	0.3905	0.6592	0.5360

Table 4. Heterogeneity Analysis

	(1) Eastern	(2) Central	(3) Western	(4) Northeastern
DID	0.0370***	0.0170*	-0.0146	0.0612**
	(0.0060)	(0.0090)	(0.0100)	(0.0253)
_cons	-0.3102***	0.1825***	-0.1065***	0.2241***
	(0.0299)	(0.0519)	(0.0390)	(0.0401)
Controls	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	1535	1343	1364	188
R^2	0.615	0.345	0.330	0.171

5 Conclusions

Considering the establishment of the first batch of National Comprehensive Demonstration Zones for the General Aviation Industry in 2017, this study finds the low-altitude economy pilot significantly enhances urban ecological resilience. Digital infrastructure is an important transmission channel, while the policy effect exhibits regional heterogeneity. It shows positive influences in the eastern regions, relatively weak in the central area, and has not yet fully emerged in the western region. Based on these findings, first, ecological governance and resilient city development should be incorporated into low-altitude economy development plans and performance evaluation systems, with particular attention to practical outcomes in pollution identification, disaster early warning and ecological restoration. Second, the low-altitude economy and digital infrastructure should be promoted by improving communication networks and processing

of environmental information. Third, differentiated regional strategies should be implemented. The eastern region should promote the large scale application of low-altitude economy. the northeastern region should leverage its aviation manufacturing base to facilitate green transformation; and the central and western regions should address deficiencies in infrastructure, skilled professionals, and supporting industries.

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