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How Does the Sharing Economy Affect Urban Carbon Emissions?—Empirical Evidence from Ride-Hailing Services

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Abstract. This paper treats the entry of ride-hailing services into cities as a quasi-natural experiment and systematically examines the causal effect of the sharing economy on urban carbon emissions based on panel data from Chinese cities spanning 2014 to 2017. The study finds that the market entry of ride-hailing services significantly reduces per capita carbon dioxide emissions in cities. This conclusion holds robust across a series of sensitivity tests. Mechanism analysis reveals that ride-hailing contributes to emission reduction primarily through two channels: optimizing industrial structure and strengthening the digital technology infrastructure. Further heterogeneity analysis indicates that this carbon-reducing effect is significantly moderated by cities' geographic and economic characteristics: its low-carbon advantage is more pronounced in large cities with dense populations and industrial agglomeration, while in smaller cities with limited market capacity and economic activity, the marginal benefits tend to diminish. This study provides micro-level empirical evidence for the green value of the sharing economy and offers valuable policy implications for how cities can leverage the sharing economy to promote sustainable development.

Keywords: Sharing Economy, Ride-hailing, Carbon Emission Reduction

1. Introduction

Against the backdrop of increasingly severe global climate change and growing constraints on resources and the environment, the contradiction between the traditional extensive economic growth model and the goals of sustainable development has become increasingly prominent. As a new economic form driven by digital technology, the sharing economy builds resource-sharing platforms to break down information barriers in traditional markets, thereby promoting the orderly flow and precise matching of idle resources between supply and demand agents, ultimately maximizing resource use efficiency. This economic logic of "use rather than ownership" fundamentally alters the traditional production and consumption patterns that are excessively dependent on resources. As such, the sharing economy can reshape resource allocation mechanisms, enhance the efficiency of economic operations, and simultaneously accelerate the development of a low-carbon and environmentally friendly growth model, thereby exerting a suppressive effect on environmental pollution [1]. This paper further investigates the impact of ride-hailing service introduction on urban per capita carbon dioxide emissions, and analyzes the underlying mechanisms and heterogeneity of the effects, providing guidance for economic transformation and low-carbon development.

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The marginal contributions of this paper are twofold: ① In terms of research focus, existing literature primarily examines the environmental benefits of shared bicycles, shared accommodation, and other forms of the sharing economy [2], while dedicated research on ride-hailing—an important manifestation of the sharing economy—remains scarce. This paper treats the entry of ride-hailing services into cities as a quasi-natural experiment, offering an in-depth analysis of their carbon emission reduction effects and underlying mechanisms. It thus provides new empirical evidence and marginal contributions to the study of carbon reduction within the sharing economy. ② In terms of analytical dimension, prior studies tend to explore heterogeneity from the perspective of differences in economic structure or development levels [3]. This paper innovatively uses urban scale as an entry point to reveal how market capacity constraints affect the marginal benefits of emission reduction, thereby offering new evidence on the spatial heterogeneity of environmental effects. Regarding mechanisms, in addition to verifying the pathway of industrial structure optimization, this paper introduces the Digital Inclusive Finance Index to confirm the enhancing role of digital technology infrastructure in reinforcing the emission-reducing effect, thereby enriching the theoretical framework concerning the coordinated development of the sharing economy, the digital economy, and the green economy. It also provides a valuable reference for the formulation of differentiated policies.

The remainder of this paper is structured as follows: Section 2 introduces the basic theoretical framework; Section 3 elaborates on the research design; Section 4 presents the empirical results and analysis; Section 5 conducts mechanism testing; and Section 6 provides conclusions and policy implications.

2. Theoretical hypothesis

As an emerging business model, the sharing economy in China is primarily categorized into three modes: shared living, shared production, and other shared services [4]. It has demonstrated significant potential in advancing the achievement of the "dual carbon" goals (carbon peaking and carbon neutrality). Existing studies have extensively examined the low-carbon effects of the sharing economy. In the field of shared mobility, research has found that shared scooters and bicycles jointly promote the development of low-carbon transportation [5], and that the widespread adoption of shared bicycles significantly reduces per capita carbon emissions while also enhancing residents' willingness to adopt sustainable transportation modes [6]. In the domain of shared space, reducing idle items and maximizing resource utilization have been shown to increase overall social welfare [1]. This peer-to-peer (P2P) sharing model, characterized by small-scale and decentralized resources, is regarded as conducive to the global decarbonization process [7]. Based on the above analysis, this paper proposes the following hypothesis:

Hypothesis 1: The sharing economy significantly promotes the development of a low-carbon economy by facilitating the transition of consumer behavior toward low-carbon practices.

The low-carbon effects of the sharing economy exhibit significant heterogeneity due to regional differences. First, urban scale is a key influencing factor. Studies have shown that the development of the sharing economy is uneven across cities of different sizes, generally declining from east to west, and in small and medium-sized cities, limited market capacity may lead to increasing marginal costs [8]. In contrast, large and mega cities benefit from more developed transportation infrastructure, the “energy-saving effect” brought about by industrial agglomeration, and different patterns of association between economic agglomeration and carbon emissions [9], thereby enjoying a comparative advantage in leveraging the emission-reduction potential of the sharing economy. Additionally, differences in the coupling between economic resilience and carbon reduction capacity

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across cities [10] also lead to varying regulatory effects of the sharing economy. Second, population density moderates the environmental benefits of the sharing economy by influencing the frequency and efficiency of sharing behavior. High population density facilitates the sharing of carbon-intensive goods and creates more opportunities for matching idle resources with demand [11], while also generating substantial demand for shared mobility. Therefore, in densely populated areas and during peak hours, the environmental benefits of the sharing economy are more pronounced.

Hypothesis 2: The low-carbon effects of the sharing economy exhibit significant urban heterogeneity, with city tier and population density positively moderating its emission-reduction impact through scale effects and demand-matching efficiency.

Technological innovation and industrial structure are key transmission pathways through which the sharing economy influences the low-carbon economy. On the one hand, technological innovation is positively correlated with economic growth [12], and technological advancement can significantly reduce carbon dioxide emissions. For example, the application of algorithms such as deep learning in the ride-hailing sector can enhance transportation efficiency by precisely matching supply and demand [13], demonstrating how digital technology directly empowers the low-carbon potential of the sharing economy. On the other hand, deep adjustments to industrial and energy structures are essential for achieving carbon peaking [14]. Upgrading industrial structures not only directly suppresses carbon emissions but also generates long-term mitigation effects by promoting the transition to a cleaner energy structure [15]. Moreover, this emission-reduction effect is subject to a threshold of green innovation—reasonable industrial structural adjustments can more effectively reduce carbon emissions.

Hypothesis 3: Technological innovation and industrial structure upgrading serve as transmission mechanisms that jointly enhance the low-carbon effects of the sharing economy by improving operational efficiency and optimizing resource allocation.

3. Model specification and data sources

3.1. Data and sample selection

To investigate the impact of ride-hailing development on cities, this paper sets the sample period from 2014 to 2017. This period represents a critical window for the development of China's ride-hailing industry, fully covering the entire process from the emergence of the shared mobility concept (2014), explosive market growth and initial regulation (2015), formal legal recognition at the national level (2016), to the comprehensive implementation of local regulatory rules and the maturation of operational models (2017). This selection ensures that the study captures the most essential evolutionary characteristics of the industry. The initial sample consists of Chinese city-level characteristic data during this period, with the following treatments applied: (1) Data from Hong Kong, Macau, and Taiwan regions were excluded; (2) For a small amount of missing data, interpolation was performed using the ARIMA model.

The core data for this study are as follows: city-level CO_2 emission data are sourced from the Center for Global Environmental Research. This database provides detailed monthly emissions in a 1 km × 1 km grid format. Based on this, we constructed the required city-level panel data for the study through spatial aggregation and statistical summation. Other variables reflecting urban economic characteristics, such as per capita GDP and industrial structure, were collected from the annual China City Statistical Yearbook.

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3.2. Model specification

This study aims to identify the causal effect of ride-hailing development on urban carbon emissions. We construct the following baseline regression model:

$$ln\left(CO_{2\_per\_capita}\right)_{i,t} = \alpha + \beta Scale_{i,t} + \sum_{j=1}^{n} \gamma_j Control_{j,i,t} + \delta_i + \theta_t + \epsilon_{i,t} \quad (1)$$

$\ln(CO_{2\_per\_capita})_{i,t}$ represents the natural logarithm of per capita carbon dioxide emissions in city i during period t. $Scale_{i,t}$ is a binary variable indicating whether ride-hailing services have entered the city during period t. The coefficient β measures the impact of the scale of ride-hailing on urban per capita carbon dioxide emissions. If this coefficient is significantly negative, it implies that the development of ride-hailing reduces per capita carbon dioxide emissions and promotes the development of a low-carbon economy.

The control variables (Control) include multiple factors that influence per capita carbon dioxide emissions, reflecting the fact that urban carbon emissions result from a combination of various influences.

Regarding the level of economic development, it is measured by the natural logarithm of per capita GDP (pergdp) in the city. Economic growth is often accompanied by increased energy consumption, which in turn affects carbon dioxide emissions. More economically developed cities typically have higher energy demands and potentially greater carbon emissions. The degree of industrialization (industry2 (%)) is represented by the share of the secondary industry's value added in the city's GDP. The industrialization level is measured by the natural logarithm of the secondary industry value (LNINDUSTRY2) and standardized using the Z-score method (ZLNINDUSTRY2). Energy use and chemical reactions during industrial production generate substantial amounts of carbon dioxide; thus, cities with a higher industrial share generally exhibit higher carbon emissions. The industrial structure (industry3 (%)) is defined as the proportion of the tertiary industry's value added in GDP. The tertiary industry's level is similarly measured by the natural logarithm of its value (ZLNINDUSTRY3) and standardized by Z-score (ZLNINDUSTRY3). Compared to the secondary industry, the tertiary industry consumes less energy and emits relatively lower carbon emissions. Therefore, upgrading and optimizing the industrial structure contribute to reducing carbon emissions. The breadth of digital financial coverage (coverage_breadth) serves as a proxy for the city's digital technology infrastructure level. This indicator essentially reflects the depth of penetration and application capability of digital technology within urban service scenarios. In the model, δ_i denotes city fixed effects, and θ_t represents time fixed effects. The error term $\epsilon_{i,t}$ captures other unobserved factors and measurement errors not accounted for in the model, and it is assumed to be independent of the explanatory variables.

4. Empirical results and analysis

To examine how the sharing economy promotes low-carbon economic development by driving the transition of consumption behavior toward low-carbon practices, this study takes ride-hailing as a representative case and constructs a panel data model. The regression results are presented in Table 1. Column (1) shows that when only the core explanatory variable is included, the coefficient of Scale is –0.0273, which preliminarily suggests that the shared nature of ride-hailing services—by integrating travel demand—has a potential suppressive effect on carbon emissions. In Column (2), after adding per capita GDP, the coefficient of Scale becomes –0.0304, indicating a strengthened

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negative effect. This suggests that after controlling for the increase in private transport emissions possibly brought about by economic growth, the emission-reduction value of ride-hailing as an alternative mode of travel becomes more clearly identifiable. Column (3) further incorporates the share of the secondary industry. The coefficient of Scale remains stable at –0.0305, revealing that the emission-reduction effect of shared mobility is relatively independent and mainly concentrated on the optimization of travel behavior on the consumption side, rather than on industrial emissions on the production side. Finally, in Column (4), after including the share of the tertiary industry, the coefficient of Scale increases in magnitude to –0.0335 and becomes statistically significant at the 10% level. This result implies that after controlling for the high-frequency travel demand associated with the development of the service sector, the emission-reduction advantage of the intensive use of ride-hailing services becomes more pronounced. In summary, the coefficient of the core explanatory variable maintains a robust and ultimately significant negative effect as control variables are gradually added. This provides strong evidence that ride-hailing services have facilitated a low-carbon transition on the consumption side by altering residents' travel behavior, thereby exerting a significant positive impact on low-carbon economic development and offering strong support for Hypothesis 1.

Table 1. Baseline regression results

Variables	peremission			
	(1)	(2)	(3)	(4)
scale	-0.0273	-0.0304	-0.0305	-0.0335*
	(0.0188)	(0.0188)	(0.0188)	(0.0188)
pergdp		0.1900**	0.1850*	0.1340
		(0.0871)	(0.108)	(0.1110)
industry2(%)			0.0003	0.0192*
			(0.004)	(0.0108)
industry3(%)				0.0211*
				(0.0112)
Time Fixed Effects	Yes	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes	Yes
Observations	831	831	831	831
R2	0.024	0.032	0.032	0.038

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.1. Heterogeneity analysis

To examine the urban heterogeneity of the sharing economy's low-carbon effects, this study conducts a grouped regression based on city size. The empirical results are shown in Table 2. For the sample of large cities, the coefficient of the core explanatory variable Scale is –0.0741 and is highly significant at the 5% level. This provides strong evidence that city tier positively moderates the emission-reduction effect. In particular, large cities are able to leverage their advantages in industrial agglomeration and technological spillovers to significantly improve the operational efficiency of

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sharing platforms, thereby achieving emission reductions at scale. By contrast, in the small city sample, the coefficient of Scale (–0.0335) is not statistically significant. This suggests that in smaller cities, limited and dispersed demand restricts the sharing economy's ability to realize scale advantages, resulting in the low-carbon potential not being effectively unleashed. Overall, the significant difference in coefficients across cities of different sizes systematically demonstrates that the low-carbon effects of the sharing economy exhibit pronounced urban heterogeneity. Its emission-reduction performance is profoundly influenced by the market size and operational efficiency determined by city tier.

Table 2. Heterogeneity test results by city size

	(1)	(2)	(3)
	Full Sample	Large Cities	Small Cities
scale	-0.0337*	-0.0741**	-0.0335
	(0.0189)	(0.0370)	(0.0241)
pergdp	0.1300	0.6820**	0.0551
	(0.1120)	(0.2790)	(0.1310)
industry2(%)	0.0186*	-0.0017	0.0290**
	(0.0110)	(0.0180)	(0.0141)
industry3(%)	0.0198*	-0.0055	0.0307**
	(0.0114)	(0.0182)	(0.0149)
Ln_density	-0.2470	0.1900	-0.2800
	(0.3230)	(0.8130)	(0.3670)
Ln_passenger_total	-0.0325	0.0511	-0.0528
	(0.0338)	(0.0611)	(0.0404)
Ln_road_total	-0.0129	-0.0303	-0.0191
	(0.0312)	(0.0601)	(0.0375)
Observations	831	221	610
R2	0.040	0.124	0.038

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2. Robustness check

To verify the robustness of the core findings, this study conducts tests by altering the measurement of industrial structure. Specifically, we replace the share of the secondary industry in the baseline model with the standardized score of the secondary industry's value added. Furthermore, we construct a model that simultaneously includes both the proportion and value-added measures of the industrial structure. Across all model specifications, the regression coefficient of the core explanatory variable Scale ranges from –0.0384 to –0.0589 and remains significantly negative. This series of tests indicates that regardless of how industrial structure is measured, the suppressive effect of the sharing economy on carbon emissions is consistently present. These findings not only enhance the credibility of the core conclusions but also provide strong empirical support for their generalizability.

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Table 3. Robustness check results

	(1)	(2)	(3)
	Model1	Model2	Model3
scale	-0.0589***	-0.0384**	-0.0425**
	(0.0214)	(0.0187)	(0.0189)
pergdp	0.2700*	0.3510***	0.2780**
	(0.1390)	(0.1060)	(0.1180)
industry2(%)	0.0250*		0.0149
	(0.0136)		(0.0109)
industry3(%)	0.0275*	-0.0032	0.0124
	(0.0144)	(0.0045)	(0.0115)
ZINDUSTRY22		-0.2540***	-0.1960**
		(0.0672)	(0.0824)
ZINDUSTRY33			-0.0572
			(0.0531)
Ln_density	-0.1630	-0.1930	-0.1420
	(0.3520)	(0.3200)	(0.3220)
Ln_passenger_total	-0.0466	-0.0357	-0.0350
	(0.0347)	(0.0335)	(0.0334)
Ln_road_total	0.0012	-0.0175	-0.0088
	(0.0340)	(0.0306)	(0.0309)
Observations	672	831	831
R2	0.049	0.059	0.064

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Mechanism analysis

To examine the transmission mechanisms through which industrial upgrading and digital technology influence the emission-reduction effects of the sharing economy, this study conducts a series of mechanism tests. The empirical results provide strong support for the theoretical hypotheses. First, we test the moderating role of industrial upgrading. The interaction term between Scale and the secondary industry is significantly positive, with a coefficient of 0.0128. This indicates that during the process of industrial upgrading, the demand from advanced manufacturing for efficient and low-carbon transportation provides structural support for the emission-reduction effect of the sharing economy. Second, we analyze the reinforcing effect of urban digital technology infrastructure. The interaction term between Scale and digital technology—measured by the Digital Financial Inclusion Index—has a large and significantly positive coefficient of 1.370. This confirms that digital technologies, through big data analytics and algorithmic optimization, effectively address the problem of information asymmetry on platforms, substantially improving operational efficiency and thus greatly enhancing the low-carbon advantage of the sharing economy. Finally, in the model

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where both mechanism variables are included simultaneously, the coefficient of Scale is –0.0404, with a strengthened negative effect and increased statistical significance. This suggests that digital technology and industrial upgrading exhibit a synergistic effect: digital infrastructure reduces the transaction costs of sharing resources across industries, enabling the energy-saving demand of the secondary sector to be efficiently matched with the emission-reduction capacity of the sharing economy, thereby amplifying the overall low-carbon effect. In summary, the empirical results clearly demonstrate that industrial upgrading provides structural support for the emission-reduction effect of the sharing economy, while digital technology significantly enhances this effect through efficiency gains. Together, these two factors form the core transmission mechanisms through which the sharing economy contributes to low-carbon development.

Table 4. Mechanism analysis results: digital infrastructure and industrial structure

	(1)	(2)	(3)	(4)
	LNINDUSTRY2	coverage_breadth		
scale	0.0128*	1.370***	-0.0344*	-0.0404**
	(0.00722)	(0.481)	(0.0188)	(0.0190)
pergdp	1.0180***	14.8500***	0.5900***	0.2280**
	(0.0339)	(2.258)	(0.141)	(0.0918)
LNINDUSTRY2			-0.3380***	
			(0.108)	
coverage_breadth				0.0013
				(0.00163)
LNINDUSTRY3	0.0159	-0.7430	-0.1310***	-0.1350***
	(0.0166)	(1.105)	(0.0430)	(0.0434)
Ln_density	0.8580***	2.1090	0.1300	-0.1620
	(0.122)	(8.094)	(0.328)	(0.317)
Ln_passenger_total	0.0028	-0.1450	-0.0292	-0.0300
	(0.0128)	(0.856)	(0.0333)	(0.0335)
Ln_road_total	0.02140*	-0.8190	-0.0057	-0.0118
	(0.0118)	(0.783)	(0.0305)	(0.0307)
Observations	831	831	831	831
R2	0.677	0.970	0.067	0.052

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6. Conclusion and policy recommendations

Promoting ride-hailing to advance the efficient development of the sharing economy can significantly reduce urban carbon emission intensity, carrying strategic importance for achieving China's dual-carbon goals and facilitating green transformation. This study systematically investigates the mechanisms through which the sharing economy impacts low-carbon economic development and finds that it reduces carbon emissions by altering residents' travel consumption behavior, curbing private car usage, and improving the efficiency of transport capacity utilization.

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This effect exhibits urban heterogeneity depending on city size: in large cities, industrial agglomeration and technological spillovers significantly enhance emission-reduction capacity, while in small cities, the effect is constrained by limited market capacity and underdeveloped digital infrastructure. Based on theoretical analysis, this study takes ride-hailing as a representative of the sharing economy and constructs a panel data regression model to examine how it influences per capita carbon emissions across different city tiers. The results show that the ride-hailing model significantly reduces per capita carbon emissions and serves as an important driver for low-carbon development and carbon neutrality—findings that are validated through robustness checks. Urban heterogeneity plays an important moderating role in the low-carbon effect. Large cities benefit from industrial agglomeration to foster a favorable ecosystem for the sharing economy, whereas small cities face limitations in supply-demand matching and the inclusiveness of digital finance, thereby constraining their low-carbon potential. Enhancing digital infrastructure and inclusive digital finance can effectively strengthen the emission-reduction performance of the sharing economy.

This study demonstrates that the sharing economy, represented by ride-hailing services, not only enables a low-carbon transformation of residents' travel behavior and reduces urban carbon emissions but also leverages digital technology and industrial synergy to build an efficient and equitable mobility ecosystem. This provides an innovative pathway for achieving the dual-carbon goals and advancing urban green transformation, significantly enhancing societal welfare in low-carbon development. Based on these findings, the following policy recommendations are proposed:①Promote coordinated reform of the ride-hailing system, deepening the integration of the sharing economy with urban transportation infrastructure and digital governance platforms. Encourage the development of smart mobility scenarios that rely on big data to optimize supply-demand matching and dispatching. Explore the integration of "sharing + public transit" connections to break service barriers and enhance emission-reduction effectiveness. Currently, data silos and fragmented operations persist between the sharing economy and traditional transportation; continuous efforts are needed to dismantle these obstacles and foster the deep incorporation of ride-hailing and similar models into the urban green transportation system. ②Advance sharing economy development by city size: in large cities, emphasize coupling with industrial ecosystems to develop customized shared mobility services and amplify agglomeration-driven emission reductions; in small cities, strengthen supporting infrastructure and market cultivation through subsidies and awareness campaigns to stimulate demand, overcome capacity constraints, and achieve coordinated low-carbon development. ③Upgrade regulation and service of the sharing economy by establishing a "service-oriented governance" system that shifts focus from approval control to service optimization and fair competition. Develop dynamic regulatory mechanisms to standardize platform operations, curb monopolistic practices, and prevent unfair competition.

This study has certain limitations. It primarily focuses on ride-hailing services and does not cover other diverse sharing economy modes such as shared accommodation, bike-sharing, and shared energy storage, which constrains a comprehensive understanding of the heterogeneous low-carbon effects within the sharing economy. Additionally, the micro-level decision-making mechanisms underlying the low-carbon transformation of consumption behaviors—such as individual preferences and social network influences—are insufficiently explored, limiting the explanatory power regarding complex real-world dynamics. Future research could expand to incorporate multiple sharing economy models and integrate micro-level consumption data and behavioral experiments to precisely elucidate the emission-reduction effects and behavioral drivers across different modes. Moreover, investigating the long-term dynamic relationship between the sharing

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economy and the dual-carbon goals, and constructing cross-period policy frameworks, would further support green transformation and upgrading.

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