Urban Renewal and Transformation of Residents' Pro-environmental Behaviors: Evidence from the Renovation of Old Residential Areas in Chengdu, China

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Article

Urban Renewal and Transformation of Residents' Pro-Environmental Behaviors: Evidence from the Renovation of Old Residential Areas in Chengdu, China

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Abstract: Based on research data from the renovation of old residential areas in Chengdu, China, this study provides empirical evidence regarding the causal relationship between urban renewal and the transformation of residents' pro-environmental behaviors. The research findings demonstrate a significant enhancement in residents' engagement in pro-environmental behaviors due to the renovation of old residential areas. Robustness tests based on replacement samples and two-stage difference-in-difference models also confirm the reliability of the conclusions. The preliminary mechanism test indicates that the mechanism of the impact of renovation of old residential areas on the transformation of residents' pro-environmental behaviors can be attributed to two main factors. Firstly, the improvement of environmental infrastructure provides residents with better conditions for participating in pro-environmental activities. Secondly, there is an elevation in residents' environmental protection awareness, prompting a more voluntary engagement in pro-environmental behavior. This study suggests that decision-makers should fully recognize that urban renewal activities nationwide are not only a process of improving urban hardware and functionality, but also a realistic and vivid "environmental education" course for the whole nation. Taking urban renewal as an opportunity to enhance citizens' awareness of environmental protection will effectively promote the transformation of pro-environmental behaviors among residents.

Keywords: urban renewal; renovation of old residential areas; pro-environmental behaviors; environmental infrastructure; environmental protection awareness

1. Introduction

Since the reform and opening up, the development model that emphasizes economic growth but not environmental protection has pushed the carrying capacity of China's resources and environment to its limits 1. Under the severe form of environmental protection, China must strike a balance between economic development and ecological environmental protection. Since the 18th National Congress of the Communist Party of China (CPC), the CPC Central Committee has elevated the construction of ecological civilization to a more prominent strategic position 2.This shift in priority has been accompanied by a series of new decisions and deployments aimed at advancing the formation of a green and low-carbon lifestyle as a key element of ecological civilization construction. The promotion of such a lifestyle has emerged as a primary focus for the CPC in the contemporary era. The 19th National Congress of the CPC report in October 2017 emphasized the importance of advocating for a simple and moderate, green and low-carbon lifestyle, while opposing extravagance, wastefulness, and irrational consumption. Subsequently, in October 2022, the CPC reiterated this stance in the report of the 20th National Congress, calling for the promotion of green and low-carbon modes of production and lifestyles. These consistent messages from the CPC leadership reflect a sustained commitment to fostering pro-environmental behaviors and practices among the populace. The CPC Central Committee's top-level designs have effectively provided strategic guidance for the widespread adoption of a green and low-carbon lifestyle throughout China. By championing sustainable living practices and encouraging eco-friendly choices, the CPC aims to cultivate a more

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environmentally conscious citizenry and contribute to the broader goal of ecological civilization development.

The formation of a green low-carbon lifestyle is a social transformation process, which not only requires government institutional design at the macro level, but ultimately needs to be realized in the practice of the public. Only when the whole society establishes the concept of low-carbon and environmentally friendly life, and actively practices pro-environmental behaviors so that it becomes the mainstream lifestyle of the society, can China consolidate the mass foundation of the society to realize the transformation of green development. So, what factors will affect the public's participation in pro-environmental behavior? Many scholars have given answers from different angles. Combing through related studies, they can be roughly categorized into the following aspects: first, socio-demographic characteristics, including gender, age, education level, income, social class status, 3 etc. Second, situational factors, including policies and regulations, social norms, interpersonal relationships, and rewards and punishments 8, etc. Third, environmental protection awareness factors, including environmental concern, environmental knowledge, environmental emotions, environmental aesthetics 12, etc.

Urban renewal is a process that cities inevitably experience at a certain stage of development. With the advancement of suburbanization in many countries, reverse urbanization has emerged, leading to an increasing number of individuals opting to relocate to the old city for residence. This trend has generated a demand for the revitalization of the urban fabric of the old city16. As an eternal topic in the process of human urbanization, urban renewal has become an important driving mechanism for urban development, and its core concept has gradually evolved from focusing only on physical space to a multidimensional process of urban protection, restoration, reuse, covering various aspects such as environmental improvement, improvement of living conditions, improvement of urban functions, and sustainable economic development 17. Based on the concept of urban renewal and its basic connotation, urban renewal does not directly aim at changing residents' pro-environmental behavioral patterns, and it is difficult to find a direct causal link between the two. In addition, few researchers have provided empirical evidence to support the idea that urban renewal is a causal factor in changing residents' pro-environmental behaviors.

On the other hand, some research indicate that residents in neighborhoods with higher environmental quality tend to possess greater environmental awareness and exhibit a greater willingness to engage in pro-environmental behaviors 18. At the same time, urban renewal undoubtedly plays a significant role in enhancing the quality of urban habitat. From this perspective, we seem to be able to find a logical correlation between urban renewal and transformation in residents' pro-environmental behaviors. Can urban renewal truly affect residents' pro-environmental behaviors. This study focuses on Chengdu, one of the first pilot cities for urban renewal in China, as its research material. It empirically examines how the renovation of old residential areas in Chengdu impacts residents' pro-environmental behaviors. The potential contribution of this study is to demonstrate that urban renewal can influence residents' pro-environmental behavioral patterns at the micro level. This expands the traditional understanding of urban renewal's impact beyond physical improvements, shedding light on the broader sphere of residents' green living attitudes and pro-environmental behavioral changes. Consequently, the study provides a novel perspective on the future trajectories of urban renewal projects.

2. Research Background and Impact Mechanisms

2.1. Research Background

In November 2021, the General Office of the Ministry of Housing and Urban-Rural Development of China issued the Notice on the First Batch of Urban Renewal Pilot Work, setting out plans to implement urban renewal pilot projects in 21 cities nationwide, including Chengdu, over a two-year period. Concurrently, in February 2022, the Chengdu Municipal Government unveiled the "14th Five-Year Plan for the Renovation of Chengdu's Old Urban Residential Areas," outlining the comprehensive renovation of old courtyards constructed before the end of 2004 in Chengdu. The

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ambitious plan aims to complete the renovation of these historic courtyards by the conclusion of 2025, with a focus on transforming approximately 2242 old courtyards, which are home to nearly 233,000 residents. This initiative not only provides a strategic roadmap for the refurbishment of old compounds in Chengdu, but also presents a detailed task breakdown, marking a significant milestone in the city's urban renewal efforts.

The renovation of old residential areas in Chengdu has been significantly accelerated with the implementation of the urban renewal pilot program, marking Chengdu as one of the pioneering cities in China. The key objectives of this program encompass a range of crucial tasks. Firstly, safety enhancement is prioritized, focusing on aspects such as power supply, drainage, fire protection, gas and housing structure. This is aimed at identifying and eliminating safety hazards to fortify the infrastructure and ensure the safety and resilience of residents in these old residential areas. Secondly, efforts are directed towards bolstering the community service functions, which involve installing elevators, establishing convenient commercial service facilities, and enhancing property management services to elevate the overall public service capacity of the community. Lastly, there is a concerted emphasis on optimizing the living environment of the community by introducing facilities for garbage classification, renovating and beautifying exterior walls, enhancing community greening initiatives, and creating greenway spaces for recreational activities. These measures collectively enhance the living conditions in the old residential areas, fostering a heightened sense of satisfaction and well-being among residents. Consequently, the transformation of old residential areas is not only becoming a cherished endeavor among the populace but also a project that genuinely benefits the community at large.

2.2. Influence Mechanisms

2.2.1. Enhancing Environmental Infrastructure

Pro-environmental behaviors, which encompass various terms such as environmentally responsible behaviors, environmentally friendly behaviors, and green behaviors, are actions aimed at minimizing negative impacts on the environment or engaging in behaviors that contribute positively to environmental conservation20. It involves the deliberate choices made by individuals, influenced by both self-imposed constraints and societal norms. Despite individuals' intentions to engage in pro-environmental behaviors, the lack of external conditions may hinder the transformation of these intentions into tangible behaviors21. For instance, Fielding conducted a study in Queensland, Australia, involving 1,008 households, which demonstrated that the presence of water-saving devices led to notable improvements in water use efficiency and reductions in wasteful practices22. Similarly, Derksen and Gartrell studied multiple residential communities in the United States and discovered that enhancing community recycling systems significantly influences residents' pro-environmental actions regarding household waste sorting and recycling23. Wu highlighted that while Chinese residents' environmental protection intentions are unaffected by travel, the accessibility of eco-friendly infrastructure in their destination plays a pivotal role in motivating their engagement in pro-environmental actions24. Moreover, Based on findings from the China General Social Survey, Cao argued that enhancing community environmental facilities is crucial for fostering residents' engagements in pro-environmental actions such as pollution reduction, resource conservation, and waste recycling25.

The improvement of the environmental infrastructure resulting from the renovation of old residential areas is the primary driver of positive change in these communities. This enhancement of the environmental infrastructure directly facilitates residents in meeting the social norms associated with pro-environmental behaviors. For example, the renovation of old residential areas has played a key role in addressing the issue of inadequate and dilapidated garbage classification facilities, which has long hindered residents from properly sorting household waste. By repairing, expanding, and enhancing the existing garbage classification facilities, the renovation projects have created a conducive environment for residents to actively engage in garbage classification practices. This initiative has not only improved the infrastructure but also empowered residents to fulfill their civic

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responsibility of proper waste disposal. Furthermore, as part of the renovation process, many communities have established grassroots environmental management organizations. Comprising community cadres, property owners and volunteers, these organizations are responsible for maintaining the environmental infrastructure. By doing so, they offer crucial hardware support that enables residents to engage in pro-environmental behaviors more effectively.

2.2.2. Raising Residents' Awareness of Environmental Protection

Environmental protection awareness plays a crucial role in shaping civic values and qualities by influencing individuals' recognition of environmental issues as well as their support for solving these problems26. It is the outcome of extensive processing of environmental information and intricate psychological processes among citizens. This encompasses individuals' subjective cognitive perceptions and behavioral intentions related to environmental concern, awareness of environmental responsibility, and environmental knowledge. Environmental protection awareness emerges as a decisive factor affecting individuals' engagement in pro-environmental behaviors27.

How does renovating old residential areas increase residents' environmental protection awareness? Firstly, the renovation of old residential areas has a direct impact on improving the quality of the neighborhood environment. This improvement is expected to enhance residents' feelings and preferences for a better ecological environment, thereby stimulating environmental protection awareness. Consequently, this impact can lead to a broader influence on residents, encouraging them to engage in various forms of pro-environmental behaviors. Moreover, the revitalization of old residential areas serves as a form of community-wide civic environmental education. To advance continual enhancement of the community environment, various promotional activities such as door-to-door outreach, owner communication groups, and public campaigns are organized within the community. These initiatives aim to heighten public environmental awareness, underscore the significance of environmental protection, and promote a sustained improvement in residents' environmental consciousnesses. Such efforts significantly contribute to augmenting residents' involvements in pro-environmental behaviors.

3. Description of Data Sources and Variables

3.1. Data Sources Description

The empirical data for this paper is derived from the research data of the National Social Science Foundation of China (NSSFC)'s funded project titled "Study on the Impact of Lack of Ecological Responsibility on Citizens' Practice of Green and Low-Carbon Lifestyles and Policy Intervention". This project 's research concentrates on tracking the evolution of Chinese residents' eco-responsibility awareness and green practices amidst economic and social changes. The primary objective is to present evidence-based recommendations to policymakers for enhancing green lifestyle initiatives. Concerning this, fieldwork was primarily conducted in Chengdu, where the project team gathered a substantial number of questionnaires for rigorous empirical scrutiny. Specifically, focusing on the revitalization of old residential areas constructed before 2004, the team randomly engaged 6-8 residents from each district of Chengdu's core urban areas (Chenghua District, Qingyang District, Wuhou District, Jinjiang District, Jinniu District) to participate in survey work during October 2022. A total of 1,025 validated questionnaires formed the foundational dataset for the empirical analysis in this paper. Subsequently, by the time the first round of questionnaires was collected, 14 old residential areas in Chengdu had completed the renovation process, encompassing 329 respondents. Concurrently, 25 old residential areas were either in progress or had not yet initiated the renovation, containing 696 respondents.

In July 2023, as the renovation of Chengdu's old residential areas progressed, 11 out of the 25 old residential areas that had not yet completed the renovation were successfully revitalized. This provides valuable material for observing the evolution of residents' pro-environmental behaviors during the urban regeneration process. A questionnaire return survey was conducted by the project team to gather insights from first-time residents residing in the residential areas that had not yet

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undergone renovation. After excluding individuals who declined participation, a valid sample of 488 respondents was obtained during the second callback. Moving forward, the study will subject the data collected from the questionnaire to a robustness test to validate the benchmark regression results.

3.2. Key Variables

3.2.1. Pro-environmental Behavior Participation Index

Scholars have adopted various approaches to define and measure pro-environmental behaviors, including energy-saving and emission reduction behaviors29, green consumption31, reduction of wastefulness33, and pro-environmental behaviors in the public sphere35. To comprehensively measure residents' participation in pro-environmental behaviors, this study established a scale encompassing 10 categories of daily pro-environmental behaviors. Table 1 illustrates the respondents' engagement in these 10 categories, allowing them to select their frequency of participation (never, occasionally, sometimes, often and always). Each option was assigned a value of 1-5 based on the frequency of participation, with higher values indicating greater involvement. In this study, the respondents' pro-environmental behavior participation index was derived by converting the ten values into a composite score through the equal-weighted weighting method. Subsequently, the deviation was standardized to ensure that all respondents' composite scores were within the range of [0,1], which were then transformed into percentage scores.

The respondents' participation in 10 categories of pro-environmental behaviors is summarized in Table 1. Variations in the level of engagement across different behaviors are evident among the interviewees. Notably, the levels of engagement in certain behaviors such as refusing to use disposable products, classifying garbage, recycling and exchanging used clothes, purchasing green products, and participating in environmental volunteering are relatively low. Specifically, the proportion of respondents who "often" or "always" refuse to use disposable products is 29.64%, while the percentage of respondents who "often" or "always" engage in garbage classification is 28.92%. Moreover, 24.24% of respondents "often" or "always" refuse to use disposable products. Additionally, there is a relatively low percentage of respondents who "often" or "always" purchase green products (18.28%), and those who "often" or "always" Participate in environmental volunteering (17.9%)

Table 1. Statistics of Residents' Pro-environmental Behaviors.

Pro-environmental behaviors	Never	Occasionally	Sometimes	Often	Always
Refuse to Use Disposable Products	16.60%	18.07%	35.69%	21.99%	7.65%
Garbage Classification	32.43%	26.29%	12.36%	19.45%	9.47%
Turn off Unused Water and Electricity	0	9.43%	12.43%	29.57%	48.57%
Recycle and Exchange Used Clothes	33.58%	26.01%	16.17%	16.25%	7.99%
Bring Your Own Shopping Bag	13.34%	22.31%	31.19%	18.54%	14.62%
Use Public Transportation	0.64%	8.31%	16.57%	34.83%	39.65%
Appropriate Air Conditioning Temperature Setting	7.07%	17.77%	12.33%	38.17%	24.66%
Purchase Green Products	11.56%	30.64%	39.52%	9.83%	8.45%
Participate in Environmental Volunteering	40.44%	32.38%	9.08%	11.21%	6.89%
Reduce Leftovers and Waste	0.37%	10.6%	17.24%	39.56%	32.23%

3.2.2. Renovation of Old Residential Areas

In this study, the core explanatory variable is a dummy variable indicating whether the respondent's residential areas has completed the renovation. Participants residing in the old residential areas that have completed the renovation are placed in the experimental group and assigned a value of 1. Conversely, those living in the old residential areas where the old renovation has not been completed are placed in the control group and assigned a value of 0.

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3.3. Control Variables

3.3.1. Characteristic Variables of Old Residential Areas

For this study, the impact of residential characteristics on respondents' engagements in pro-environmental behaviors was examined by selecting two indicators of residential quality. The indicators chosen were the number of years since the old residential areas was established and the standard of property fees imposed in the old residential areas. These indicators were crucial in assessing the living environment of the old residential areas and their influence on individuals' pro-environmental behaviors.

3.3.2. Socio-demographic Variables

In this study, demographic characteristics such as gender, age, and marital status are examined to determine their impact on residents' pro-environmental behaviors. The observation group consists of female and married respondents who are assigned a value of 1, while the remaining groups form the control group with a value of 0. Moreover, control variables such as years of education, income, social class identity, political profile, and type of residence are introduced in this study. The years of education corresponds to the highest level attained, with assigned values as follows: illiteracy (0), elementary school (6), junior high school (9), senior high school (12), university (16), master's degree (19), and doctor's degree (22). Social class identity is subjectively evaluated through specific questionnaire items, assigning a value of 1 to 10 based on respondents' self-perception of their social standing, with higher values indicating a higher perceived social class. The political profile variable distinguishes between CPC members and non-CPC members, with CPC members serving as the observation group and non-CPC members as the reference group. Additionally, the type of residence is categorized as own property or others' property, with own property designated as the observation group and others' property as the reference group.

3.3.3. Variables of Environmental Protection Awareness

To control the impact of individual environmental protection awareness factors on respondents' engagement in pro-environmental behaviors, this study incorporates various dimensions of environmental protection awareness, including environmental knowledge, environmental concern, and environmental responsibility. The study developed an environmental protection knowledge scale comprising 10 items, and respondents were scored 1 for correct answers and 0 for incorrect or unknown responses. The scores for the 10 questions were aggregated and standardized using deviation standardization, resulting in values within the range [0,1]. Subsequently, these standardized scores were converted into a percentage scores to establish the personal environmental knowledge index. In terms of assessing environmental concern, participants were asked about their level of concern regarding environmental issues, each assigned a value from 1 to 5 based on the level of agreement expressed(not at all concerned, not too concerned; somewhat concerned; quite concerned, extremely concerned).Furthermore, respondents were asked about their beliefs regarding citizen responsibility for environmental protection. Responses were rated on a scale from 1 to 5, with values indicating different levels of perceived responsibility towards environmental protection(not at all, a little, moderately, quite a lot, very much).

3.4. Descriptive Statistics of Variables and Tests of Balance

The differences in descriptive characteristics between experimental group and control group are presented in Table 2. In terms of residential characteristics, there is no significant difference between experimental group and control group in terms of both the years of the old residential areas were built and property fees. Residents in the experimental group were significantly better than the control group in terms of years of education, income, and subjective social class identity. Additionally, the probability of owning their own home was significantly lower than that of the control group. Furthermore, residents in the experimental group displayed higher levels of environmental concern

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and environmental responsibility compared to the control group. The differences in 6 out of 13 control variables indicate a potential impact of sample unbalance on the regression results. To address this issue, the study employed outlier removal and difference-in-differences model in a robustness test in the subsequent section to re-estimate the parameters and enhance the reliability of the baseline regression findings.

Table 2. Descriptive Statistics of Variables.

Variables	Full Sample		Experimental Group		Control Group		Difference	
	N	Mean	N	Mean	N	Mean	Mean	T-Value
Pro-environmental Behavior Participation Index	1025	32.976	329	36.562	696	31.281	5.281***	2.732
Age of the Old residential areas	1025	29.182	329	28.537	696	29.487	-0.95	-1.053
Property Fee (yuan/m^2)	1025	0.445	329	0.504	696	0.417	0.087	0.875
Age	1025	43.679	329	43.908	696	43.571	0.337	-0.227
Female	1025	0.466	329	0.497	696	0.452	0.045	1.390
Married	1025	0.754	329	0.765	696	0.749	0.016	0.437
Years of Education	1025	11.195	329	11.479	696	11.061	0.418***	4.087
Self-owned House	1025	0.608	329	0.586	696	0.619	-0.033*	-1.955
Income (in ten thousands yuan)	1025	6.796	329	7.347	696	6.535	0.812***	2.903
CPC Member	1025	0.077	329	0.082	696	0.075	0.007	1.329
Social Class Identity	1025	4.439	329	4.507	696	4.407	0.101***	3.695
Environmental Knowledge	1025	40.507	329	41.386	696	40.092	1.294	1.133
Environmental Concern	1025	3.225	329	3.476	696	3.106	0.037***	3.443
Environmental Liability	1025	3.376	329	3.544	696	3.296	0.248***	4.916

Notes: *, **, *** denote significance at the 10, 5 and 1 percent levels, respectively (two-tailed).

4. Empirical analysis

4.1. Benchmark regression methods

The study conducted a benchmark regression analysis using the OLS model to examine the impact of the renovation of old residential areas on residents' participation in pro-environmental behaviors. The dependent variable was the pro-environmental behavior participation index, with the key explanatory variable being a dummy variable representing whether the old residential areas had completed renovation. Table 3 presents the benchmark regression results. Model in column (1) solely evaluates the effect of the renovation of old residential areas on residents' pro-environmental behavioral participation. Model in column (2) includes controls for residential characteristics, while model in column (3) introduces controls for socio-demographic characteristics. Finally, model in column (4) incorporates the individual awareness of environmental protection variable. Across all models, the results consistently indicate that the renovation of old residential areas significantly enhances residents' engagement in pro-environmental behaviors. For instance, in column (4), the data reveals a substantial increase of 2.2182 points in residents' pro-environmental behavior participation scores following the renovation of old residential areas, which represents an average improvement of approximately 6.73% when compared to the sample mean of 32.967 in Table 2.

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Table 3. Benchmark Regression Results.

	（1）	（2）	（3）	（4）
Experimental Group	3.1742***	3.0113***	2.5416***	2.2182***
	(0.6611)	(0.5134)	(0.4924)	(0.4167)
Age of the Old Residential Areas		-0.6092***	-0.3187**	-0.2027**
		(0.2077)	(0.1476)	(0.1012)
Property fee (yuan/m2)		4.2186***	3.6877***	2.7167**
		(1.2337)	(1.2256)	(1.3229)
Age			-0.1672***	-0.1284***
			(0.0406)	(0.0319)
Female			0.6294**	0.5651*
			(0.3172)	(0.0301)
Married			-0.5767	-0.3729
			(0.7251)	(0.4187)
Years of Education			0.5899***	0.4022***
			(0.1077)	(0.1023)
Self-owned House			0.9212***	0.6071***
			(0.2492)	(0.2162)
Income (in millions of dollars)			0.6421***	0.3728***
			(0.2145)	(0.1252)
CPC Member			4.4199***	3.7229***
			(1.2267)	(1.1954)
Social Class Identity			0.3207**	0.2667**
			(0.1447)	(0.1225)
Environmental Knowledge				0.3157***
				(0.0915)
Environmental Concern				0.7109***
				(0.1654)
Environmental Liability				0.6422***
				（0.1927）
Obs.	1025	1025	1025	1025
R2	0.0481	0.0871	0.1974	0.2215

Notes: Standard errors are presented in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent levels, respectively (two-tailed). The same as below.

In the benchmark regression results, it was also found that various factors influenced residents' participation in pro-environmental behaviors. Firstly, residents living in neighborhoods with longer ages and lower property fees exhibited lower levels of participation in pro-environmental behaviors. This aligns with the study's anticipated outcome, indicating that residents residing in neighborhoods with superior habitat quality generally demonstrate higher engagement in pro-environmental practices. Moreover, socio-demographic variables also played a significant role in determining residents' engagements in pro-environmental activities. Specifically, younger individuals and females demonstrated higher levels of participation in pro-environmental behaviors. Additionally, higher education levels, income levels, ownership of housing, Communist party membership and social class identity were associated with increased participation in pro-environmental actions. Contrarily, marital status did not have a significant impact on residents' participation in pro-environmental behaviors. Lastly, environmental protection awareness such as individual environmental knowledge, environmental concern, environmental responsibility were identified as crucial drivers that significantly enhance residents' involvements in pro-environmental activities.

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4.2. Robustness Tests

4.2.1. Excluding Abnormal Samples

Table 2 revealed significant differences between experimental group and control group across 6 out of the 13 control variables. This study suggests that the basis of pro-environmental behavioral participation may differ between experimental group and control group due to sample imbalance. The unbalanced sample in this study may be attributed to the influence of the policy's screening effect on the selection of targets for renovating old residential areas. This effect led to the prioritization of neighborhoods with better living environments and less renovation difficulties for inclusion in the old residential areas renovation project. Consequently, residents in these residential areas typically possess a stronger foundation of environmental behavioral participation. As a result, the sample imbalance may lead to an incorrect attribution of the higher levels of residents' environmental behavioral participation to the renovation of old residential areas.

To test the robustness of the previous regression conclusions, this study conducts sequential reruns of the regression by excluding respondents residing in abnormal old residential areas. Specifically, the model in column (1) excludes respondents living in old residential areas with high-quality school district resources, followed by column (2) excluding respondents living in old residential areas constructed through pooled funds from state-owned units. Subsequently, column (3) excludes respondents residing in the Chengdu City Garbage Classification Demonstration Neighborhoods, and finally, column (4) excludes respondents living in neighborhoods falling under the aforementioned categories.

Table 4. Robustness Test Based on Excluding Abnormal Community Interference.

	（1）	（2）	（3）	（4）
Experimental Group	1.9168***	1.9569***	1.8918***	1.7706**
	(0.6344)	(0.6054)	(0.5019)	(0.7167)
Residential Characteristics	YES	YES	YES	YES
Socio-Demographic Characteristics	YES	YES	YES	YES
Environmental Protection Awareness	YES	YES	YES	YES
Obs.	912	983	947	834
R^2	0.2281	0.2107	0.2015	0.2169

After re-testing the samples with abnormal old residential areas removed, the study discovered that the coefficient representing the influence of renovating old residential areas on residents' participation in pro-environmental behaviors exhibited a slight decrease. This suggests that the exclusion of samples from these abnormal neighborhoods did not compromise the robustness of the benchmark regression findings. In essence, the findings reinforced the conclusion that the renovation of residential areas significantly enhances residents' engagements in pro-environmental behaviors.

4.2.2. Re-testing Based on Difference-in-Differences Model

In order to further mitigate sample selection bias from policy screening factors, this study conducted a robustness test using a difference-in-differences model. In July 2023, residents who resided in old residential areas that had not yet undergone renovation during the initial visit were subsequently interviewed via a web-based questionnaire. The second survey, conducted as part of the follow-up, focused on collecting information specifically pertaining to the residents' degrees of engagement in pro-environmental practices. Notably, the initial visit had already established the foundational socio-statistical variables, rendering the subsequent survey exclusive to gauging the residents' environmental behaviors. The study successfully secured a sample of 488 returning respondents during the second visit, providing a robust pool of data for analysis. By leveraging the data collected from both survey instances, the research adopted a standard two-period difference-in-differences model to evaluate the impact of renovating old residential areas on residents'

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participation in pro-environmental behaviors. This analytical approach offers the advantage of accounting for individual unobservant differences and mitigating the influence of time-varying factors, thereby enabling a more precise assessment of the policy effects. Furthermore, employing this model helps diminish potential issues related to selection bias and endogeneity, ultimately enhancing the accuracy of the policy evaluation.

The study introduces a time dummy variable, which is assigned a value of 1 if the result of the second visit and 0 if the result of the first visit. Table 5 shows the results of the robustness tests obtained based on the two-period difference-in-differences model. The result of interest for the study is the coefficient of the interaction term between the core explanatory variables and the time variable, which reflects the policy effect of the renovation of old residential areas in terms of its impact on the pro-environmental behaviors of the residents. The results show that this coefficient is still significantly positive, and the robustness test using two-period difference-in-differences model does not deviate from the conclusion obtained from the benchmark regression that renovating old residential areas significantly boosts residents' participation in pro-environmental behaviors.

Table 5. Robust Test Based on Two-Period Difference-in-Differences Model.

	（1）	（2）	（3）	（4）
Experimental Group*Time	2.5824***	2.3116***	2.1239***	1.6682**
	(0.7245)	(0.7019)	(0.6624)	(0.6149)
Experimental Group	0.3976**	0.3278**	0.1767	0.1415
	(0.1767)	(0.1502)	(0.1661)	(0.1709)
Time	0.6744***	0.5482***	0.3852**	0.2809**
	(0.1458)	(0.1896)	(0.1769)	(0.1364)
Residential Characteristics	NO	YES	YES	YES
Socio-demographic Characteristics	NO	NO	YES	YES
Environmental Protection Awareness	NO	NO	NO	YES
Obs.	976	976	976	976
R^2	0.0719	0.1049	0.2783	0.3583

4.3. Preliminary Study on Impact Mechanisms

Through the empirical analysis, this study determined that the renovation of old residential areas has a notable impact on enhancing residents' engagements in pro-environmental behaviors. As analyzed earlier, the renovation of old residential areas impacts residents' pro-environmental behavior participation in two possible ways. Firstly, by enhancing environmental infrastructure, the renovation creates more favorable external conditions that encourage residents to engage in pro-environmental behaviors. Secondly, the renovation contributes to raising residents' awareness of environmental protection. Which pathway does it affect residents' participation in pro-environmental behaviors, or both? This study offers a preliminary validation.

First, this study argues that if the renovation of old residential areas can elevate participation in pro-environmental behaviors by enhancing the environmental infrastructure within these communities, its influence on pro-environmental behaviors, particularly those closely tied to improvements in the environmental infrastructure, will be more pronounced. Therefore, this study investigated how renovation of old residential areas affects various forms of pro-environmental behavior. The study resets the assignment of the dependent variables by assigning a value of 1 to individuals who "always" or "often" engaged in certain types of pro-environmental behaviors, representing more frequent participation, and a value of 0 for less frequent participation. Consequently, the PROBIT model was selected for regression analysis, and the explanatory variables chosen aligned with those in the prior section. The regression results in Table 6 show that old residential areas renovation has a significantly greater impact on two specific pro-environmental behaviors, garbage classification and recycling and exchanging used clothes, compared to other pro-environmental behaviors. Specifically, the renovation of old residential areas has resulted in increased rates of more frequent participation in garbage classification and recycling and exchanging

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of used clothes by 17.42% and 10.27% respectively. Concurrently, there has been a 1.22% to 6.18% increase in the rate of more frequent participation in other pro-environmental behaviors.

Table 6. The Influence of Renovating Old Residential Areas on Specific Pro-Environmental Behaviors.

Pro-environmental behaviors	Coefficient	Control Variables	Pseudo R^2	Obs.
Garbage Classification	0.1742***(0.0506)	YES	0.309	1025
Recycle and Exchange Used Clothes	0.1027***(0.0328)	YES	0.254	1025
Participate in Environmental Volunteering	0.0618**(0.0303)	YES	0.278	1025
Refuse to Use Disposable Products	0.0379**(0.0168)	YES	0.231	1025
Turn Off Unused Water and Electricity	0.0517**(0.0229)	YES	0.248	1025
Bring Your Own Shopping Bag	0.0278**(0.0131)	YES	0.232	1025
Use Public Transportation	0.0133(0.0519)	YES	0.187	1025
Appropriate Air Conditioning Temperature Setting	0.0419***(0.0132)	YES	0.192	1025
Purchase Green Products	0.0167*(0.0097)	YES	0.204	1025
Reduce Leftovers and Waste	0.0122**(0.0059)	YES	0.229	1025

Notes: The estimated coefficients represent the marginal effects derived from the Probit model.

Why does the renovation of old residential areas lead to increased participation in these two types of pro-environmental behaviors to a greater extent? It can be seen that the level of participation in these two behaviors is closely linked to the enhancement of the related environmental infrastructure. For instance, one notable aspect of this renovation is the refurbishment, expansion, and smart upgrading of garbage classification facilities. Such upgrades create an improved environment conducive to residents actively participating in garbage classification initiatives. Meanwhile, the addition of waste clothing recycling bins during the renovation of old residential areas, as well as the active maintenance and initiatives of the community and property owners, have created the hardware conditions for residents to participate in the pro-environmental behavior of recycling and exchanging waste clothing. These results demonstrate that the renovation of old residential areas can enhance residents' engagements in pro-environmental behaviors by enhancing environmental infrastructure.

Can renovating old residential areas increase residents' engagements in pro-environmental behaviors by raising awareness of environmental protection? To validate this channel, the study investigated how renovating old residential areas affects residents' awareness of environmental protection in terms of environmental knowledge, concern, and responsibility. The regression results in Table 7 reveal a significant positive effect of the renovation of old residential areas on residents' awareness of environmental protection across different dimensions of individual environmental protection awareness. This indicates that the renovation of old residential areas has the potential to impact residents' participation in pro-environmental behaviors on a broader scale. A key implication of these findings is that urban renewal presents a significant opportunity to foster the concept of green living among residents through their personal experiences. During urban renewal initiatives, policymakers can leverage improvements in urban habitats as compelling environmental education resources to enhance public awareness of environmental protection. This strategy can effectively encourage individuals to engage in pro-environmental behaviors more spontaneously.

Table 7. Influence of Renovation of Old Residential Areas on Residents' Environmental Protection Awareness.

	(1) Environmental Knowledge	(2) Environmental Concern	(3) Environmental Liability
Experimental Group	0.8268***	0.0744**	0.1244**

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	(0.2446)	(0.0337)	(0.0516)
Residential Characteristics	YES	YES	YES
Socio-demographic Characteristics	YES	YES	YES
Obs.	1025	1025	1025
R^2	0.2447	0.2635	0.2105

5. Conclusion and Discussion

In March 2021, China's "14th Five-Year Plan" was released, featuring the explicit inclusion of urban renewal actions as one of the 102 major projects. This significant decision by China's central government not only symbolized the elevation of urban renewal to a national strategy but also marked a new chapter in China's urban and rural development. Chengdu being one of the pioneering cities for urban renewal initiatives, has identified the renovation of old residential areas as a key focus area and task within this framework. The study conducted research on the renovation of old residential areas in Chengdu's main urban region, revealing that this process not only enhances the human environment but also plays a role in increasing residents' engagements in pro-environmental activities to some extent. Through further analysis, it was determined that the positive influence of old residential areas renovation on residents' pro-environmental behaviors stems from two main sources. Firstly, the enhancement of environmental infrastructure contributes to this impact, while secondly, there is a notable rise in residents' environmental protection awareness due to the renovation efforts.

This study concludes, based on its findings, that urban renewal serves not only as a means of enhancing urban infrastructure and functionality but also as a pivotal opportunity to reshape the populace's contemporary living principles and eco-friendly behaviors. In light of this, urban renewal should be leveraged to galvanize the enhancement of both physical and social aspects within old residential areas, thereby cultivating a more habitable environment. Authorities ought to seize the occasion presented by urban renewal to elevate the quality of urban living through initiatives such as environmental enhancement, infrastructure upgrades, and services enhancement in old residential areas. By fostering an environment conducive to pro-environmental actions, a sense of community engagement and contentment can be instilled among residents, leading to a nurturing of affection and concern towards their surroundings and fostering increased participation in pro-environmental behaviors, thereby facilitating the widespread adoption of sustainable lifestyles. Simultaneously, decision-makers should integrate urban renewal efforts with the reinforcement of grassroots community environmental governance structures, clearly defining roles and responsibilities for maintaining environmental quality within communities. By establishing enduring and scientifically sound management frameworks tailored to the nuances of older neighborhoods, the efficacy of renovation efforts can be upheld over time, fostering an environment conducive to sustained pro-environmental practices among residents.

In addition, urban renewal is a multifaceted, long-term social process that impacts a large population, serving as an extensive "environmental education" platform for the entire community. This process provides a significant window for residents to shape their perspectives on sustainable living. Within the realm of urban renewal, instilling an understanding of ecological importance, environmental accountability, and relevant environmental knowledge can fundamentally bolster citizens' environmental consciousness, fostering greater engagement in pro-environmental behaviors. Policymakers should capitalize on public involvement in urban renewal initiatives to encourage alignment with heightened environmental consciousness among residents.

Strategies such as integrating environmental education into the urban renewal process and using the media to publicize the results of the renovation of old residential areas have collectively enhanced residents' understanding of environmental protection. These initiatives have played a crucial role in stimulating residents' awareness of environmental protection and promoting environmentally friendly behaviors. Furthermore, they have also facilitated the dissemination of environmentally friendly lifestyles within the community.

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