RESEARCH ON URBAN CARBON LOCK-IN INDEX SYSTEM AND GOVERNANCE APPROACH

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This Independent Study Has Been Approved as a Partial Fulfillment of the Requirements for the Degree of Master of Business Administration

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ABSTRACT

With the intensifying global response to climate change and China's dual carbon goals—carbon peak by 2030 and carbon neutrality by 2060—urban carbon emissions and their systemic inertia have become central concerns in environmental governance. This study, grounded in Institutional Transition Theory and behavioral response models, aimed to explore the impact of carbon lock-in index, environmental awareness, publicity and education, and demographic characteristics on enterprise acceptance of low-carbon transition. A structured questionnaire survey was distributed to Beijing residents using a stratified random sampling method, resulting in 385 valid responses. The study employed a quantitative research design with SPSS for descriptive statistics, correlation analysis, and multiple linear regression to test the hypotheses. Results showed that carbon lock-in system significantly negatively influenced acceptance of low-carbon transition, while environmental awareness, publicity and education positively influenced acceptance. Demographic factors including income and education level also showed notable effects. The findings provide insights and recommendations for urban carbon governance, including constructing a carbon lock-in index system to identify bottlenecks and promote sustainable development in Chinese cities.

Keywords: carbon lock-in, carbon neutrality, environmental awareness, publicity and education, low-carbon transition, enterprise acceptance

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JIE LIU

DECLARATION

I, LIU JIE, hereby declare that this Independent Study entitled "Research on Urban Carbon Lock-in Index System and Governance Approach" is an original work and has never been submitted to any academic institution for a degree.

(LIU JIE)
Feb 20, 2025

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1.1 Background of the Study

With the continued progression of global industrialization, the volume of greenhouse gas emissions has significantly increased, which has further exacerbated the trend of global warming—particularly in the Northern Hemisphere. Since 1971, temperature anomalies have become increasingly apparent (see Figure 1.1), bringing climate change to the forefront of international concern. Since the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, the international community has since signed several landmark agreements, including the Paris Agreement (2015). These agreements underscore the shared responsibility and collective efforts of nations around the world to combat climate change.

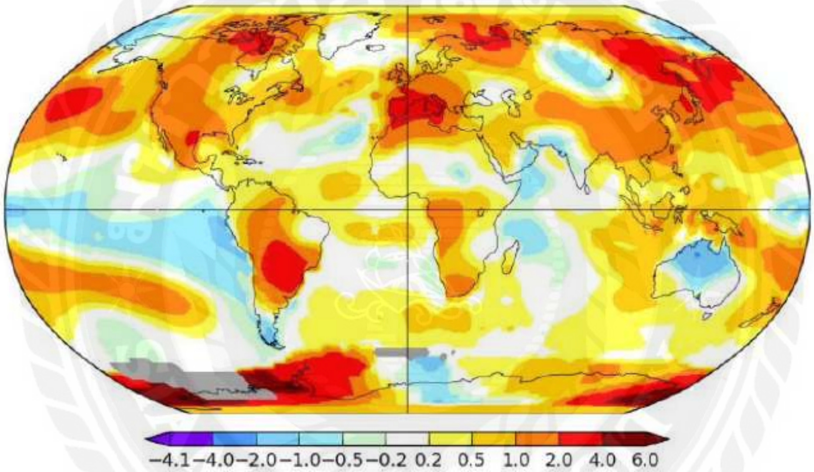

Figure 1.1 L-OTI (℃) Anomaly vs 1971-2022

Source: NASA (2022)

Against this backdrop, the global trend of greenhouse gas emissions varies significantly across regions. China, as the world's largest developing country, has experienced rapid economic growth in recent decades, while concurrently facing increasingly severe environmental challenges. Amid rapid urbanization, cities have emerged as major contributors to greenhouse gas emissions. A substantial share of carbon emissions originates from urban infrastructure development, energy consumption, and transportation systems (Li et al., 2024). Since 1975, China's carbon dioxide emissions have risen sharply, and in 2006, the country surpassed the United States to become the world's largest carbon emitter (see Figure 1.2). As a result, cities serve not only as engines of economic growth but also as epicenters of carbon emissions and environmental degradation. Effectively addressing urban carbon emissions through well-designed policies and technological innovation has therefore become a key prerequisite for achieving carbon peaking and carbon neutrality goals (Li et al., 2024; Wang et al., 2021).

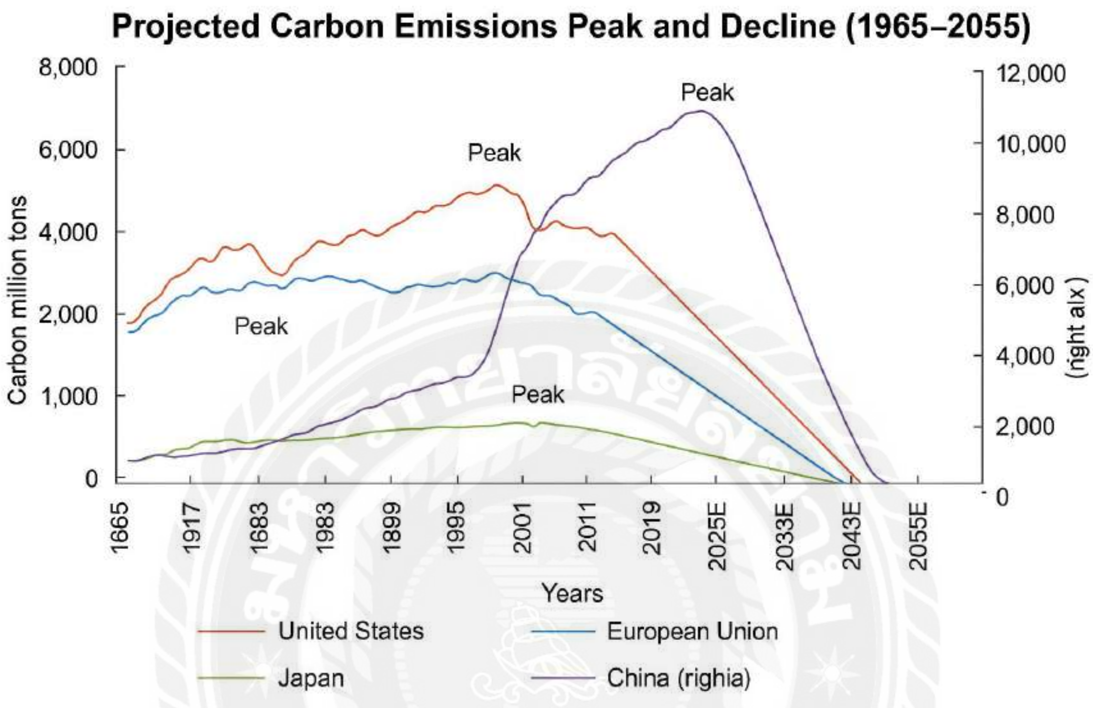

Figure 1.2. Total Carbon Emissions Across Major Countries.
Source: Everbright Securities (2021)

Urbanization is often accompanied by a concept known as carbon lock-in, which refers to the persistence of high-carbon development patterns formed throughout long-term urban growth, thereby constraining a city's capacity to reduce emissions in the short term (Jin, 2024). This effect primarily results from structural inertia in infrastructure, energy systems, and industrial composition. For example, a fossil-fuel-dominated energy mix, carbon-intensive industrial arrangements, and inefficient transportation systems make it difficult for cities to transition rapidly to low-carbon pathways (Shang & Lv, 2023). In China's context, cities function as engines of economic development while simultaneously facing growing environmental pressures. Thus, breaking the constraints of carbon lock-in has become a crucial challenge for sustainable urban development both domestically and globally.

Globally, many countries and regions have begun addressing urban carbon emissions and exploring pathways toward low-carbon transformation. For instance, the 28 member states of the European Union have achieved net reductions in carbon emissions over the past four decades through effective policy frameworks and technological innovation (European Commission, 2016). However, in China, the high-carbon development model remains deeply embedded in its socio-economic structures. The lock-in effect is especially pronounced in areas such as energy consumption, industrial upgrading, and urban transport (Dong et al., 2023). Thus, overcoming carbon lock-in and facilitating green, low-carbon transitions are now pivotal to achieving China's "dual carbon" goals of peaking carbon emissions and reaching carbon neutrality.

Table 1.1 Annual Carbon Dioxide Emissions (Unit: Thousand Tons)

Country	1975	1985	1995	2005	2015	growth rate
China	1,218,349	1,900,003	3,303,544	6,174,717	10,641,789	773%
the USA	4,537,030	4,691,155	5,294,648	5,886,318	5,172,338	14%
EU 28	4,364,970	4,480,659	4,126,226	4,214,608	3,469,671	-21%
World	17,433,822	20,330,298	23,603,529	29,792,009	36,061,710	107%

Source: European Commission (2016)

In addition, since the Chinese government announced its goals of peaking carbon emissions by 2030 and achieving carbon neutrality by 2060, cities—as major sources of emissions—have become central to national policy agendas (China National Energy Administration, 2020). The question of how cities can contribute to the realization of these ambitious goals is now a key topic of interest in both academic and policy-making communities. Notably, the development of a scientifically grounded Carbon Lock-In Index system—designed to quantitatively assess urban emission trajectories at various stages of development—is emerging as a critical approach for identifying and overcoming carbon lock-in in the context of climate change mitigation.

Urban carbon lock-in refers to high-carbon development patterns that result from long-term dependence on existing infrastructure, industrial layouts, and energy configurations. These patterns constrain a city's ability to transition to low-carbon development in the short term. More than a purely technical challenge, the carbon lock-in effect is deeply rooted in broader economic and social structures. Thus, understanding and breaking this lock-in cycle is crucial for achieving sustainable low-carbon urban transitions.

This study focuses on the development of an integrated carbon lock-in index system for cities and explores how targeted governance frameworks can help dismantle carbon lock-in and accelerate urban low-carbon transitions. By quantitatively assessing the degree of carbon lock-in under China's specific urban development conditions, the research seeks to offer both theoretical insights and actionable policy recommendations for urban carbon reduction in China and other developing economies.

1.2 Questions of the Study

1. Does carbon lock-in index have a positive impact on enterprises' acceptance of low-carbon transition?

2. Does environmental awareness positively influence enterprises' acceptance of low-carbon transition?

3. Do demographic factors have a positive impact on enterprises' acceptance of low-carbon transition?

4. Do publicity and education positively influence enterprises' acceptance of low-carbon transition?

1.3 Objectives of the Study

1. To examine the positive impact of carbon lock-in index on enterprises' acceptance of low-carbon transition.

2. To examine the influence of low-carbon environmental awareness on enterprises' acceptance of low-carbon transition.

3. To explore the effect of demographic factors on enterprises' acceptance of low-carbon transition.

4. To examine the impact of carbon neutrality publicity and education on enterprises' acceptance of low-carbon transition.

1.4 Scope of the Study

This study adopted a quantitative research approach through a structured questionnaire to examine the phenomenon of carbon lock-in and its governance under the background of China's "Dual Carbon" goals, with a specific focus on Beijing. The primary objectives included: 1) constructing a carbon lock-in index to quantify the degree of path dependence and lock-in effect in the city's carbon emission patterns, and 2) examining the effectiveness of low-carbon governance practices, including the role of environmental awareness, public participation, and knowledge dissemination, in addressing urban carbon lock-in.

The study was grounded in the theoretical frameworks of Path Dependence Theory and Theory of Planned Behavior (TPB). Four independent variables were established: 1) carbon lock-in index, 2) low-carbon environmental awareness, 3) demographic factors, and 4) carbon neutrality knowledge and publicity & education. The dependent variable is the acceptance of low-carbon transition among enterprises, used to evaluate the overall public and institutional willingness to embrace sustainable development practices in a carbon-constrained context.

A total of 385 valid responses were collected from residents of Beijing through a stratified sampling method. The study covered individuals of varying age groups, gender, education levels, occupations, and income categories. The data were analyzed using descriptive statistics, correlation analysis, and regression analysis, providing empirical insights into how structural and cognitive factors interact to influence low-carbon transition acceptance.

This research was conducted from January to May 2025. The early stages involved literature review and survey design, followed by data collection in March 2025. Data analysis and result interpretation were completed by May 2025. The study aimed to provide practical recommendations and theoretical guidance for urban carbon governance and low-carbon policy design, particularly in developing country contexts such as China.

1.5 Significance of the Study

1.5.1 Theoretical Significance

In recent years, as climate change has become an increasingly urgent global issue, research on carbon emission reduction and greenhouse gas mitigation has gained growing attention. While a significant body of work has explored areas such as low-carbon economic systems, policy design, and carbon management, research focusing specifically on urban carbon lock-in and the development of carbon lock-in index frameworks remains relatively limited. Urban carbon lock-in is deeply rooted in long-term patterns of industrial structure, energy dependency, and transportation layout—all of which have a critical impact on the feasibility of low-carbon urban transitions.

In the context of China's "Dual Carbon" goals, this study developed a Carbon Lock-In Index to quantitatively assess the degree of path dependence in urban carbon emissions. This framework addresses a notable research gap and offers a novel theoretical lens through which the mechanisms of urban carbon lock-in can be understood. Furthermore, the study incorporates the dimension of low-carbon environmental awareness, analyzing how various governance tools—such as policy mechanisms, technological innovations, and public participation—can support urban decarbonization. Accordingly, the research contributes to strengthening the theoretical link between carbon reduction strategies and the sustainable development of cities.

1.5.2 Practical Significance

As the world's largest carbon emitter, China faces considerable challenges in achieving its carbon peaking and carbon neutrality objectives, particularly in densely populated urban areas. With the acceleration of urbanization, many Chinese cities are experiencing severe carbon lock-in effects stemming from their dependence on traditional energy structures, industrial patterns, and transportation systems. These challenges complicate efforts to initiate effective low-carbon transitions.

This study provides a practical and implementable Carbon Lock-In Index framework, developed through a case study of Beijing. The index enables policymakers and urban planners to better identify structural barriers to carbon reduction and to formulate more targeted and efficient carbon governance strategies. Additionally, by evaluating the synergistic role of policies, technologies, and public engagement within low-carbon environmental awareness, the study illustrates how cities can more effectively navigate their transition toward sustainability.

Breaking the cycle of urban carbon lock-in not only facilitates the achievement of China's "Dual Carbon" goals but also promotes green economic development and enhances the long-term sustainability of urban governance. The theoretical and empirical contributions of this study are expected to provide meaningful references for other cities undergoing similar low-carbon transitions, thus advancing the broader global effort toward building sustainable, low-carbon urban systems.

1.6 Definition of Key Terms

1. Carbon Lock-In Index:

This refers to the degree to which urban systems are constrained by existing high-carbon infrastructures, technologies, and institutional practices. It quantifies the extent of path dependency in energy use, industrial structures, and transportation networks that inhibit a transition to low-carbon alternatives.

2. Environmental Awareness:

This is defined as an individual's or organization's understanding of environmental issues, including knowledge of climate change, sustainability, ecological degradation, and the importance of environmentally responsible behavior. It reflects cognitive, emotional, and behavioral sensitivity toward environmental protection.

3. Demographic Factors:

Demographic factors refer to the statistical characteristics of a population that are used to identify and classify individuals within a study. These variables help researchers understand how personal or contextual backgrounds may influence perceptions, behaviors, or outcomes.

The demographic factors in this study include gender, age, marital status, education level, occupation, and monthly income, which are used to analyze how individuals' backgrounds may shape their responses to publicity and education initiatives for promoting low-carbon awareness and practices.

4. Publicity and Education:

In this study, publicity and education refer to structured efforts undertaken by governments, media, NGOs, or enterprises to raise environmental awareness, disseminate knowledge, and influence public attitudes toward low-carbon behaviors. These efforts include public campaigns, educational programs, media engagement, and training sessions aimed at fostering pro-environmental practices.

5. Acceptance of Low-Carbon Transition:

This concept captures the willingness and readiness of individuals or enterprises to support, adopt, and implement practices that contribute to a transition from high-carbon to low-carbon development models. It reflects attitudes toward sustainability, policy adoption, and behavioral change in response to climate goals.

Chapter 2 Literature Review

This study aims to investigate the phenomenon of carbon lock-in and its governance in Beijing under the framework of China's "dual carbon" goals, with a particular focus on how these factors influence enterprises' acceptance of low-carbon transition. This chapter provides a comprehensive analysis of four key dimensions—Carbon Lock-In Index, Environmental Awareness, Demographic Factors, and Publicity and Education—in relation to their influence on low-carbon transition acceptance among enterprises.

First, the chapter outlines the fundamental theories and definitions related to the core variables and examines how each factor influences enterprises' willingness to adopt low-carbon practices. Based on this theoretical foundation, a conceptual model is developed to explain the determinants of low-carbon transition acceptance, and corresponding research hypotheses are proposed. Finally, the chapter reviews relevant literature, providing an overview of previous research findings and offering a theoretical basis for the subsequent empirical investigation.

As current academic literature offers limited research on carbon lock-in indices and awareness of carbon-neutral products, this study draws insights from related domains such as low-carbon economy, carbon reduction policy, and consumer behavior. By integrating the specific urban context of Beijing, this research aims to explore how these variables impact enterprises' transition behavior and to contribute policy-relevant recommendations for facilitating low-carbon transformation in urban governance.

2.1 Carbon Lock-in Index

In recent years, the concept of carbon lock-in has gained increasing scholarly and policy interest, especially in the context of achieving global carbon neutrality goals. Carbon lock-in refers to the structural and institutional constraints that reinforce the use of carbon-intensive infrastructure and technologies, thereby hindering the transition to low-carbon alternatives (Felkner et al., 2024). Within this framework, the Carbon Lock-in Index has emerged as a valuable analytical tool to quantify the extent to which cities or regions remain dependent on high-carbon development patterns.

Urban areas, particularly those experiencing rapid development, are highly susceptible to carbon lock-in due to long-term investments in energy systems, transportation networks, and land-use planning (Felkner et al., 2024). These infrastructure decisions tend to establish path-dependent trajectories that are difficult to reverse in the short term. As a result, measuring the degree of carbon lock-in has become essential for understanding where policy interventions are most needed and how structural transformation can be facilitated.

To operationalize this concept, researchers have proposed index-based evaluation models that integrate multiple dimensions—such as fossil fuel reliance, industrial energy intensity, infrastructure rigidity, and governance responsiveness. For instance, Chen et al. (2023) developed an empirical model tailored to Chinese cities, combining indicators related to energy use, planning flexibility, and institutional innovation. Their findings suggest that cities with diverse economic bases and proactive low-carbon policies tend to exhibit weaker lock-in effects and greater adaptability.

In a similar vein, Seto et al. (2021) introduced a spatially detailed version of the index, assessing carbon lock-in at the district level within metropolitan areas. This localized approach enables more granular governance and supports the formulation of targeted decarbonization strategies. Their research also highlights that overcoming lock-in is not merely a matter of upgrading technologies—it requires deeper systemic change, including regulatory reforms and public engagement.

Building on these insights, Gonsalves (2023) argued that the Carbon Lock-in Index can serve not only as a diagnostic tool but also as a strategic planning instrument. By enabling comparative analysis across cities and time periods, the index helps governments identify structural bottlenecks and craft tailored low-carbon pathways that align with national "dual-carbon" goals.

In sum, the carbon lock-in index provides a critical lens for evaluating the entrenched barriers to decarbonization in urban environments. Its application is particularly relevant in China, where the interaction between rapid urbanization and climate governance presents both significant challenges and transformative opportunities.

2.2 Environmental Awareness

Sia et al. (1986) proposed the Environmental Literacy Model, which draws on pedagogical theories to identify the factors influencing environmental awareness. The model comprises three major categories and eight sub-components. The three main categories are: cognitive components (environmental knowledge, ecological knowledge, and strategic environmental knowledge), affective components (attitudes, values, beliefs, and environmental sensitivity), and personality-related variables (locus of control).

Environmental awareness encompasses both understanding and sensitivity toward the natural environment and environmental issues. It is useful for researchers in evaluating how concerned consumers are about environmental problems and how well they understand existing environmental conditions (Ramli et al., 2022). Through surveys, researchers assess whether consumers pay attention to environmental issues and whether they feel concerned about them, thereby identifying factors that influence their willingness to purchase carbon-neutral products (Will et al., 2022). Environmental knowledge includes knowledge of the natural environment, environmental issues, and environmental actions. It represents a systematic understanding, particularly concerning resources, environmental challenges, and their potential solutions.

In conclusion, environmental awareness refers to consumers' comprehensive understanding of carbon-neutral concepts, product attributes, functions, and labeling systems, as well as their overall knowledge and sensitivity toward environmental issues.

2.3 Demographic Factors

Demographic factors are an essential dimension for analyzing behavioral differences among consumers. They help identify individual traits and support researchers in segmenting target groups, ultimately revealing how such traits influence low-carbon transition acceptance. Wang et al. (2021) and Wang et al. (2024) emphasized in their studies on low-carbon transition and carbon lock-in that demographic variables—including gender, age, education, occupation, and income—can effectively distinguish levels of acceptance toward low-carbon policies and carbon reduction initiatives. Existing research consistently shows that low-carbon acceptance varies significantly across demographic segments.

In low-carbon transition studies, demographic characteristics not only reflect consumers' personal attributes but also signal their social status. These dimensions help explain how individuals adopt low-carbon behaviors in response to policies, technologies, or sociocultural contexts. This study focuses on six key demographic variables: gender, age, marital status, occupation, monthly income, and education level. Based on survey data, the research investigates how these characteristics influence enterprises' willingness to adopt low-carbon transformation strategies.

Studies have found that enterprise-level low-carbon transition acceptance is significantly correlated with income and education. Higher levels of income and education are typically associated with a greater openness to adopt low-carbon policies and to invest in sustainable innovation. In contrast, limited income and lower educational attainment may hinder an enterprise's ability to implement such changes (Zhao et al., 2022). Additionally, Zhao et al. noted that gender and age may also influence attitudes toward transition, with female managers and younger business leaders more likely to support environmental initiatives and climate policies.

Marital status and household structure may also shape how decision-makers engage with low-carbon practices (Schulte et al., 2022). For example, de Abreu et al. (2021) observed that individuals with greater family responsibilities tend to adopt a more cautious approach to new policies, prioritizing stability and cost efficiency. On the other hand, those without dependents—such as unmarried or child-free decision-makers—may be more willing to embrace innovative low-carbon technologies and experimental policies.

In summary, demographic variables significantly influence enterprises' willingness to adopt low-carbon transformation. Within the context of carbon lock-in governance, examining these variables helps uncover behavioral patterns and decision-making attitudes related to low-carbon adoption. Insights drawn from this analysis can inform more targeted and effective policy design, ultimately supporting a smoother and more inclusive urban low-carbon transition.

2.4 Publicity and Education

Recent studies have highlighted the significant role of publicity and education in shaping consumer behavior towards low-carbon products. For instance, a study by Peng et al. (2025) emphasizes that consumer orientation and market-driven strategies, including effective publicity, are crucial in promoting low-carbon innovations within supply chains. Similarly, research by Zhao et al. (2022) indicates that targeted educational campaigns can enhance consumers' understanding and acceptance of carbon-labeled products, thereby influencing their purchasing decisions.

Moreover, policy satisfaction has been identified as a key factor affecting residents' low-carbon behavior. A study by Lin et al. (2024) reveals that when the public perceives policies as satisfactory and well-communicated, there is a higher likelihood of adopting low-carbon behaviors. Additionally, exposure to climate change impact photographs has been shown to trigger low-carbon awareness and behaviors among individuals, underscoring the power of visual educational tools in promoting environmental consciousness.

These findings collectively suggest that well-structured publicity and educational initiatives are effective in fostering consumer engagement with low-carbon products and behaviors. By enhancing awareness and providing clear information, such strategies can bridge the gap between environmental knowledge and actionable consumer choices.

2.5 Theory Review

To comprehensively understand the challenges of urban carbon lock-in and the factors influencing public acceptance of low-carbon transitions, this study is grounded in two interrelated theoretical frameworks: Path Dependence Theory and Theory of Planned Behavior (TPB). Together, they offer a multi-level analytical perspective—one that captures both the structural inertia embedded in urban systems and the behavioral intentions of individuals and organizations navigating decarbonization.

1. Path Dependence Theory

Path Dependence Theory, initially conceptualized by Arthur (1989), highlights how historical decisions, particularly in infrastructure and technological systems, can generate self-reinforcing processes that constrain future options (Pittroff, 2021). In urban contexts, investments in high-carbon infrastructure—such as fossil-fuel-based power grids, car-oriented transportation networks, and energy-intensive buildings—

often lead to a state of carbon lock-in, where switching to low-carbon alternatives becomes difficult and costly (Puffert, 2024).

This theoretical lens is particularly relevant in rapidly developing cities like Beijing, where urban expansion, industrial structure, and centralized energy systems have created path-dependent trajectories. Seto et al. (2021) emphasized that overcoming lock-in requires more than the introduction of green technologies; it demands holistic transformation through policy reform, institutional restructuring, and long-term governance planning. In this research, Path Dependence Theory forms the conceptual foundation for the carbon lock-in index, which quantifies the degree to which a city's carbon-intensive systems are resistant to change.

2. Theory of Planned Behavior (TPB)

While path dependence addresses systemic barriers, understanding public acceptance of low-carbon transitions requires a psychological perspective. Theory of Planned Behavior (TPB), proposed by Ajzen (1991), offers a robust framework for predicting human behavior in environmental decision-making (Gansser & Reich, 2023). According to TPB, an individual's intention to perform a certain behavior is influenced by three factors: attitude toward the behavior, subjective norms, and perceived behavioral control (Purwati & Angelina, 2021).

In this study, TPB helps interpret how awareness of environmental awareness, and public education shape individuals' willingness to support low-carbon lifestyles and policies. For example, a resident who believes in the environmental value of low-carbon choices, feels social encouragement, and perceives themselves capable of making such changes is more likely to adopt sustainable behaviors. This model is essential for analyzing behavioral variance among Beijing residents in response to carbon governance efforts.

By integrating these two frameworks, this study not only assesses the structural rigidity embedded in urban systems through path dependence, but also explores the psychosocial drivers of behavior through TPB. This dual perspective allows for a more holistic understanding of why carbon lock-in persists and how public acceptance can be cultivated to support policy and technological shifts.

2.6 Research Relevant

Wang et al. (2024), in their large-scale behavioral survey across China, emphasized the pivotal role of individual low-carbon behaviors in reducing carbon emissions. Their study showed that both internal (e.g., attitudes, perceived control) and external (e.g., infrastructure, policy, incentives) factors significantly influence personal willingness to adopt low-carbon practices, especially in urban environments such as Beijing. These findings reinforce the importance of social-psychological drivers and demographic differences in supporting carbon reduction goals.

Abdullah et al. (2022), in their study of low-carbon city governance in Malaysia, highlighted that local governments play a central role in coordinating urban sustainability efforts through institutional frameworks. Their case study of Shah Alam demonstrated that effective urban governance, combined with community participation and policy consistency, is key to achieving low-carbon objectives. This insight parallels challenges faced by major Chinese cities, including Beijing, in translating top-level carbon policies into localized actions.

Seto et al. (2021) developed a spatially disaggregated Carbon Lock-in Index to measure carbon rigidity within different urban districts. Their findings revealed significant intra-city disparities in carbon lock-in levels, reinforcing the idea that spatial planning and governance flexibility are crucial to effective decarbonization. Their methodology provides a replicable framework for evaluating Beijing's own internal variations in carbon dependence.

A recent study by Chen et al. (2023) introduced a comprehensive measurement system for carbon lock-in using entropy-weighted indicators across Chinese provinces. Their results confirmed that the extent and type of carbon lock-in have a nonlinear impact on green economic efficiency, suggesting that policy effectiveness depends on local contexts and lock-in typologies. This approach supports the development of refined urban carbon management strategies based on structural assessment.

In conclusion, recent literature consistently demonstrates that carbon lock-in is not only a technological or infrastructural issue but also a behavioral and institutional one. The carbon lock-in index serves as a powerful tool to evaluate cities' structural constraints in reducing emissions, while behavioral and governance studies emphasize the importance of environmental cognition, public engagement, and multi-level policy coordination. For cities like Beijing, successful low-carbon transition depends on both structural reform and cultivating a socially aware, behaviorally supportive public. Therefore, future urban governance strategies must be integrative, addressing physical, institutional, and human dimensions to effectively break through carbon dependency and foster long-term sustainability.

2.7 Conceptual Framework

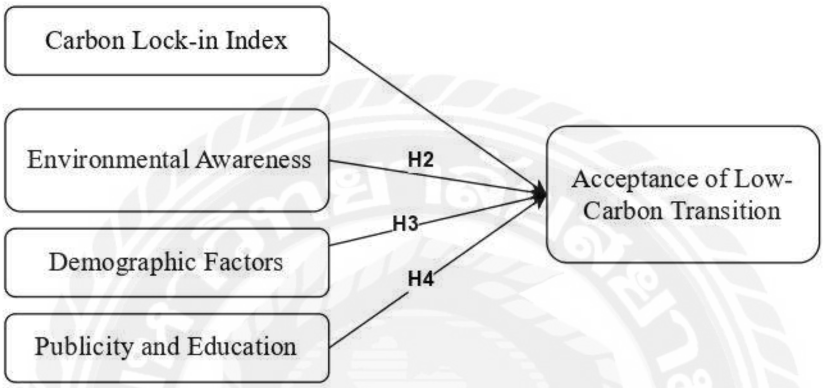

Figure 2.1 Conceptual Framework

Chapter 3 Research Methodology

3.1 Research Design

This study adopted a quantitative research approach to investigate how carbon lock-in, environmental awareness, and governance-related variables influence enterprises' acceptance of low-carbon transition in the context of China's "Dual Carbon" strategy. Specifically, the study focused on Beijing as a representative urban case due to its advanced industrial development and significant carbon emissions profile.

A structured questionnaire survey was designed to collect empirical data from residents in Beijing, encompassing multiple demographic backgrounds. The survey instrument was developed based on existing validated scales and tailored to the specific constructs of this study, including Carbon Lock-In Index, Environmental Awareness, and Publicity and Education. The dependent variable was the Acceptance of Low-Carbon Transition among urban enterprises and residents.

Through this structured design, the study aimed to provide empirical evidence on the factors affecting low-carbon transition acceptance, offering both theoretical contributions and practical recommendations for carbon governance in urban China.

3.2 Population and Sample

This study employed a quantitative research method to investigate consumer acceptance of low-carbon transition, focusing on the attitudes and behaviors of Beijing residents in the context of the "dual carbon" goals. The target population consisted of urban residents, representing various consumer groups with different ages, genders, income levels, and educational backgrounds. A simple random sampling method was used to ensure that the sample was representative of the diverse demographic groups. The data collected reflected the acceptance of low-carbon policies, low-carbon products, and low-carbon lifestyles among Beijing residents.

The sample size was determined using the Yamane formula, ensuring a 95% confidence level and a 5% margin of error, which resulted in a sample size of 385 participants. To meet the minimum required sample size, the study ensured the diversity of the sample, including participants from different regions and social groups, thereby enhancing the representativeness and applicability of the research results.

$$N = \frac{N}{1+(Ne2)}$$

(Equation 3-1)

3.3 Hypothesis

H1: There is a significant relationship between carbon lock-in index and consumers' acceptance of low-carbon transition.

H2: There is a significant relationship between environmental awareness and consumers' acceptance of low-carbon transition.

H3: There is a significant relationship between demographic factors and consumers' acceptance of low-carbon transition.

H4: There is a significant relationship between publicity and education and consumers' acceptance of low-carbon transition.

3.4 Research Instrument

This study aimed to investigate how four independent variables—carbon lock-in index, environmental awareness, demographic factors, and publicity and education—influence the dependent variable, acceptance of low-carbon transition. Since acceptance reflects respondents' subjective attitudes and behavioral intentions, a questionnaire survey is considered the most suitable method for collecting effective primary data.

The questionnaire survey involved using a structured survey instrument to collect data, including measurement scales for each variable and respondents' demographic characteristics. The questionnaire consists of closed-ended items and adopts a five-point Likert scale, where options 1 to 5 correspond to: Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree. The quality of the measurement scale is essential, as it directly affects the accuracy and validity of the findings. Therefore, ensuring the reliability of the scale is a critical element of this research.

To guarantee the quality of the questionnaire, the instrument is informed by extensive literature related to low-carbon transition and policy, particularly in areas involving carbon-neutral product behavior and consumer acceptance. Based on the theoretical framework involving the four independent variables (carbon lock-in index, environmental awareness, demographic factors, publicity and education) and the dependent variable (acceptance of low-carbon transition), a clear and comprehensible questionnaire was designed to ensure respondents could easily interpret each item.

The final questionnaire includes five sections and a total of 30 items, consisting of both closed-ended and scaled items.

Section 1 presents an introduction, outlining the survey's purpose, instructions, confidentiality assurance, and an appreciation for participation.

Section 2 contains a screening question to confirm that the respondent resides in Beijing; only those who do continue with the survey (1 item).

Section 3 collects demographic data, covering gender, age, marital status, education level, occupation, and monthly income (6 items).

Section 4 is the main body of the questionnaire and includes measurement items for carbon lock-in index, environmental awareness, and publicity and education, all assessed using the five-point Likert scale (23 items).

The carbon lock-in index is evaluated along two dimensions: carbon emission path dependence and barriers to low-carbon transformation, reflecting the extent to which past infrastructure and policy decisions constrain present transition efforts.

The environmental awareness variable is based on the measurement instruments developed in previous studies, particularly those by Li et al. (2024), as shown in Table 3.1-3.4.

Table 3.1 Measurement Items for Carbon Lock-In Index

Variable	Measurement Items
Carbon Lock-in Index	CLI1. I believe that a shift toward low-carbon production models (e.g., using renewable energy) can significantly improve the environment.
	CLI2. I believe that efforts by enterprises to reduce carbon emissions can enhance their market competitiveness.
	CLI3. I believe that reducing reliance on traditional high-carbon energy sources can increase consumer recognition of the enterprise.

Variable	Measurement Items
	CLI4. I believe that adopting low-carbon technologies and green production processes can help build public trust in the low-carbon transition.
	CLI5. I believe that breaking away from traditional carbon-intensive development paths through innovation and technological transformation will promote low-carbon transition and attract greater consumer support.

Table 3.2 Measurement Items for Environmental Awareness

Variable	Measurement Items
Environmental Awareness	EA1. I believe that low-carbon transition by enterprises is crucial for environmental protection and can reduce the negative impacts of carbon emissions.
	EA2. I believe that low-carbon transition by enterprises can not only mitigate climate change but also improve air quality and the ecological environment.
	EA3. I believe that low-carbon production and consumption models can help enterprises reduce resource waste and promote sustainable development.
	EA4. I believe that understanding the significance of low-carbon transition can increase my acceptance of low-carbon products from enterprises.
	EA5. I believe that enterprises' low-carbon transition contributes to ecological protection and promotes green development for the future society.

Table 3.3 Measurement Items for Publicity and Education

Variable	Measurement Items
Publicity and Education	PE1. I frequently hear or see publicity related to corporate low-carbon transition.
	PE2. Information obtained from journals, newspapers, and media about policies and technological promotion related to corporate low-carbon transition makes me more willing to support such initiatives and participate in relevant actions.
	PE3. I support the introduction of stronger national policies to encourage both enterprises and individuals to actively participate in the low-carbon transition, reduce carbon emissions, and promote the widespread adoption of low-carbon technologies and products.

Table 3.4 Measurement Items for Acceptance of Low-Carbon Transition

Variable	Measurement Items
Acceptance of Low-Carbon Transition	ALT1. I am willing to participate in Beijing's low-carbon transition initiatives and adopt a corresponding low-carbon lifestyle.
	ALT2. I support the joint efforts of the government and enterprises in promoting low-carbon policies and technologies to facilitate the transition.
	ALT3. I am willing to pay a higher price for low-carbon products because I believe they are beneficial to the environment.
	ALT4. I am willing to change traditional high-carbon consumption behaviors and support the adoption and application of low-carbon technologies.
	ALT5. I believe that the low-carbon transition is an effective approach to addressing climate change, and I am willing to actively participate in it.

3.5 Reliability and Validity Analysis of the Scale

3.5.1 Reliability Analysis

Reliability refers to the consistency and stability of measurement results across different conditions and time periods. In this study, Cronbach's Alpha coefficient was employed to assess the internal consistency reliability of the scale. A Cronbach's Alpha value closer to 1 indicates stronger internal consistency, and a value above 0.70 is generally considered acceptable for social science research.

This study calculated the Cronbach's Alpha coefficients for four key dimensions: Carbon Lock-In Index, Environmental Awareness, Publicity and Education, and Acceptance of Low-Carbon Transition, in order to verify the internal consistency of the measurement scale. The results of the reliability analysis are presented in Table 3.5.

Table 3.5 Reliability Test of Questionnaire

Variable	Question items	Cronbach's Alpha
Carbon Lock-in Index	5	0.846
Environmental Awareness	5	0.862
Publicity and Education	3	0.809
Acceptance of Low-Carbon Transition	5	0.855
total	23	0.911

As shown in Table 3.5, all variables have Cronbach's Alpha coefficients exceeding the recommended threshold of 0.70, indicating that the scale has strong internal consistency and is highly reliable. Among the dimensions, Environmental Awareness records the highest reliability coefficient at 0.862, followed closely by Acceptance of Low-Carbon Transition (0.855), all reflecting excellent reliability.

The Carbon Lock-In Index dimension also showed robust reliability with a Cronbach's Alpha of 0.846, and Publicity and Education achieved acceptable internal consistency at 0.809. Furthermore, the overall reliability of the questionnaire, based on all 23 items, reaches 0.911, demonstrating that the scale is highly consistent and statistically reliable.

In conclusion, the Cronbach's Alpha values for all variables exceeded 0.80, far above the minimum threshold of 0.70, confirming that the scale used in this study provides a reliable measurement tool for further validity testing and empirical analysis.

3.5.2 Validity Analysis

To ensure the validity of the questionnaire used in this study, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity were employed. The KMO test evaluates the adequacy of sampling for each variable in the model and for the complete model. A KMO value above 0.70 is considered acceptable, while values above 0.80 indicate a high level of suitability for factor analysis. Meanwhile, a significant result ($p < 0.05$) in Bartlett's Test confirms that the data is suitable for structure detection and factor extraction.

The validity test results for the four dimensions in this study are presented in Table 3.6.

Table 3.6Validity Test of Questionnaire

Dimension	KMO Statistic Value	Bartlett's Test of Sphericity (Approx. Chi-Square)	df	Sig.
Carbon Lock-in Index	0.862	709.943	10	0.000
Environmental Awareness	0.874	800.622	10	0.000
Publicity and Education	0.710	381.513	3	0.000
Acceptance of Low-Carbon Transition	0.863	771.284	10	0.000
total	0.912	4048.093	253	0.000

As shown in Table 3.6, all research dimensions present KMO values well above the acceptable threshold of 0.70, indicating a strong level of sampling adequacy. Notably, the KMO value for Environmental Awareness is the highest at 0.874. Publicity and Education also meets the minimum requirement with a KMO value of 0.710, indicating acceptable sampling adequacy.

Additionally, Bartlett's Test of Sphericity yields p-values less than 0.001 across all variables, confirming that the inter-item correlations are statistically significant and suitable for structure detection. The overall KMO value of 0.912 and the Chi-Square statistic of 4048.093 further reinforce the appropriateness of applying factor analysis to this dataset and affirm the construct validity of the measurement scale.

In conclusion, the results of both KMO and Bartlett's tests demonstrate that the questionnaire possesses high construct validity, providing a robust foundation for further empirical analysis in this study.

3.6 Data Collection

The data collection for this study was carried out over a period of three weeks in March 2025. The survey was administered using Wenjuanxing, a well-known online questionnaire platform in China. To ensure broad accessibility and engagement, the questionnaire was distributed through multiple channels, including QR codes, WeChat groups, and direct messages, with the aim of reaching a diverse population of residents living in Beijing.

A total of 450 questionnaires were distributed. After eliminating incomplete or invalid responses, 385 valid questionnaires were collected, resulting in a valid response rate of 85.6%. This rigorous data collection process helped ensure that the sample was both reliable and representative, thereby providing a solid empirical foundation for the statistical analysis conducted in the following chapters.

3.7 Data Analysis

3.7.1 Descriptive Statistical Analysis

Descriptive statistical analysis involves organizing, summarizing, describing, and interpreting the collected sample data. In this study, detailed statistical descriptions of the distribution of demographic variables (gender, age, education level, marital status, occupation, monthly income, etc.) were necessary. The main measures included frequencies and percentages to provide an overview of the population characteristics and their potential influence on the acceptance of low-carbon transition.

3.7.2 Independent Sample T-Test

The independent sample T-test, also known as the two independent-sample T-test, is commonly used to compare the means of two independent samples. It is used to determine whether the means of two groups differ significantly. In this study, the independent sample T-test was used to compare the differences in low-carbon transition acceptance between different demographic groups (gender, age, income level) to determine if significant differences exist in their acceptance of low-carbon policies and practices.

3.7.3 One-Way ANOVA (Analysis of Variance)

One-way ANOVA is used to analyze the impact of a single factor on the outcome variable. It tests whether there are any statistically significant differences between the means of three or more independent groups. In this study, one-way ANOVA was applied to explore how different factors such as carbon lock-in index, low-carbon environmental awareness, and environmental awareness affect the acceptance of low-carbon transition. The analysis determined if these factors have a significant influence on how urban residents perceive and accept low-carbon initiatives.

3.7.4 Correlation Analysis

Correlation analysis helps to analyze the strength of the relationship between two or more related variables. It is a statistical method used to examine the relationships among variables within a model. In this study, SPSS software was used to perform correlation analysis using the Pearson correlation coefficient to assess whether there was a significant relationship between the independent variables (carbon lock-in index, low-carbon environmental awareness, publicity and education) and the dependent variable (acceptance of low-carbon transition). This analysis helped to determine the degree of association among variables and to test whether the proposed hypotheses were supported by empirical data.

3.7.5 Regression Analysis

This study employed SPSS software to conduct regression analysis with the aim of testing the validity of the proposed theoretical model and identifying the key factors influencing enterprises' acceptance of low-carbon transition. As a widely used statistical method, regression analysis enables researchers to quantify the relationships between multiple variables and determine the specific impact of each explanatory variable on the outcome variable. In this study, particular attention was given to carbon lock-in index, environmental awareness, and publicity and education, examining how they collectively influence enterprises' willingness to embrace low-carbon transformation. By analyzing the direction and strength of these relationships, the research reveals the relative importance of each factor in shaping enterprise decision-making and provides a solid quantitative foundation for hypothesis testing and further discussion. At the same time, the analysis accounts for the presence of random influences, ensuring that the model maintains a balance between theoretical rigor and real-world applicability.

Chapter 4 Findings and Discussion

This chapter presents the major empirical findings of the study, based on a comprehensive data analysis process involving descriptive statistics, correlation analysis, linear regression analysis, independent samples t-tests, and one-way ANOVA tests. The objective of the analysis is to investigate how four key independent variables—Carbon Lock-in Index, Environmental Awareness, Publicity and Education, and Demographic Characteristics—influence the dependent variable: Acceptance of Low-Carbon Transition among enterprises in Beijing, under the national Dual-Carbon Goals.

A total of 385 valid responses were obtained through the structured questionnaire, meeting the required sample size for statistical analysis and ensuring the reliability and generalizability of the data. The analysis results provide a clear understanding of how various factors impact enterprise attitudes toward low-carbon transformation, revealing both the overall acceptance level and differences across demographic groups such as gender, age, education, income, and occupation. These findings offer both theoretical insights and practical implications for promoting low-carbon governance in urban China.

4.1 Findings

4.1.1 Demographic Characteristics of Respondents

Descriptive statistical analysis is an important tool for understanding the individual characteristics of respondents and the overall characteristics they represent. In this study, the data from 385 valid questionnaires were integrated and analyzed, covering various demographic characteristics including gender, age, marital status, education, occupation, monthly income, and regional distribution. Table 4.1 below shows the distribution of these demographic characteristics, followed by a detailed analysis. Based on the statistical results, the following key conclusions are drawn:

Gender:

Among the respondents, 52.2% were male and 47.8% were female, which indicates a relatively balanced gender distribution. This suggests that the sample adequately represents both male and female perspectives.

Age:

The age distribution of the respondents is quite diverse. 40% of respondents were aged between 30 and 39 years, while 27.5% were between 26 and 35 years old. Additionally, 11.2% of respondents were aged over 55 years, indicating that the sample includes both younger and older groups, providing a broad perspective on the low-carbon behavior of different age demographics.

Marital Status:

Regarding marital status, 66.5% of respondents were married, while 33.5% were single. This indicates that the majority of the sample is married, which may influence their perspectives on low-carbon behavior and policy acceptance, given that married individuals might have different social and economic dynamics than singles.

Education:

Regarding education, 53.3% of respondents had at least a bachelor’s degree, with 40.3% holding a bachelor’s degree and 13% possessing a master’s degree or higher. This suggests that the sample is highly educated, which may influence respondents’ environmental awareness and their attitudes toward adopting low-carbon behaviors.

Occupation:

The majority of the respondents were either corporate employees or freelancers, with 30.4% working in corporate settings and 16.9% being freelancers. This indicates that most respondents are engaged in full-time work or entrepreneurship. In addition, 23.4% worked in government or public institutions, and 12.1% were involved in other occupations, showing a diverse occupational background among the respondents.

Monthly Income:

In terms of monthly income, the largest group of respondents (41.8%) had a monthly income between 8,000 and 12,000 RMB, followed by 24.4% whose monthly income was between 5,000 and 8,000 RMB. This income distribution indicates that the sample includes a broad spectrum of income levels, which is important for understanding their purchasing behavior and acceptance of low-carbon initiatives.

Regional Distribution:

Regarding regional distribution, 57.1% of respondents came from urban areas, while 42.9% were from rural areas. This balance between urban and rural respondents ensures a comprehensive view of how regional differences might impact attitudes toward low-carbon policies and behaviors.

Table 4.1 Demographic Characteristics of Respondents

Attitude	Classification Indicators	Frequency	Percent
Gender	Male	201	52.2%
	Female	184	47.8%
Age	18-25 years old	10	2.6%
	26-35 years old	106	27.5%
	36-45 years old	154	40.0%
	46-55 years old	72	18.7%
	56 years and above	43	11.2%
Marital Status	Single	129	33.5%
	Married	256	66.5%
Education	High school or below	64	16.6%
	Associate degree	96	24.9%
	Bachelor’s degree	155	40.3%
	Master’s degree or above	50	13.0%
Occupation	Student	10	2.6%
	Corporate employee	45	11.7%
	Freelancer	65	16.9%
	Government employee / Public institution staff	90	23.4%
	Private sector employee	117	30.4%
	Other (e.g., self-employed)	52	13.5%
Monthly Income	Below 2,000 RMB	13	3.4%
	2,000-5,000 RMB	22	5.7%
	5,000-8,000 RMB	94	24.4%
	8,000-12,000 RMB	161	41.8%
	12,000-17,000 RMB	62	16.1%
	Above 17,000 RMB	33	8.6%

4.1.2 Descriptive Statistics of Variables

Descriptive statistical analysis was conducted using SPSS software to analyze the mean and standard deviation of each measurement item, reflecting the respondents' response levels to each influencing factor. A total of 385 valid questionnaires were collected, all of which were complete with no missing values. All measurement items used a Likert five-point scale, ensuring the representativeness of the data. The detailed results are presented as follows:

Table 4.2 Descriptive Statistics of Variables

Statistics	Carbon Lock-in Index	Environmental Awareness	Publicity and Education	Acceptance of Low-Carbon Transition
Mean	3.92	3.89	3.73	3.94
Std. Deviation	0.88	0.93	1.03	0.88

According to Table 4.2, carbon lock-in index primarily examines consumers' awareness of carbon lock-in phenomena. The analysis of carbon lock-in index reveals that the mean value is 3.92 with a standard deviation of 0.88. This relatively high mean suggests that respondents have a good understanding of carbon lock-in, with a low level of individual variation in their responses.

Environmental Awareness measures consumers' understanding and concern for environmental issues. The mean value for Environmental Awareness is 3.89, with a standard deviation of 0.93, which reflects a high level of concern among respondents for environmental issues, although individual perceptions vary moderately.

Publicity and Education refers to the impact of promotional efforts and education about carbon-neutral products on consumers' purchasing behavior. The mean score for Publicity and Education is 3.73, with a standard deviation of 1.03, suggesting that, on average, respondents believe that publicity and education have a moderate impact on their purchasing intentions. The broader variation indicates that the influence of educational efforts may differ across individuals.

Acceptance of Low-Carbon Transition measures consumers' willingness to support and engage in the transition to low-carbon products. The mean value for Acceptance of Low-Carbon Transition is 3.94, with a standard deviation of 0.88, suggesting a relatively high level of acceptance among respondents for low-carbon transitions, with a low degree of variation in their responses.

4.1.3 Regression Analysis

This study used Pearson correlation analysis to examine the relationships between the variables. The correlation results for Carbon Lock-in Index, Awareness of Environmental Awareness, Publicity and Education, and Acceptance of Low-Carbon Transition are shown in Table 4.8. Pearson correlation coefficients range from 0 to 0.3 (weak correlation), 0.3 to 0.5 (moderate correlation), and 0.5 to 1 (strong correlation).

Table 4.3 Correlation Analysis of Variables

Variables	Carbon Lock-in Index	Environmental Awareness	Publicity and Education	Acceptance of Low-Carbon Transition
Carbon Lock-in Index	1	.363**	.378**	.390**
Sig. (2-tailed)	-	.000	.000	.000
N	385	385	385	385
Environmental Awareness	.363**	1	.398**	.467**
Sig. (2-tailed)	.000	-	.000	.000
N	385	385	385	385
Publicity and Education	.378**	.398**	1	.405**
Sig. (2-tailed)	.000	.000	-	.000
N	385	385	385	385
Acceptance of Low-Carbon Transition	.390**	.467**	.405**	1
Sig. (2-tailed)	.000	.000	.000	-
N	385	385	385	385

Correlation is significant at the 0.01 level (2-tailed).

Based on the correlation analysis in Table 4.3, the following conclusions can be drawn:

Publicity and Education shows a moderate positive correlation with both Carbon Lock-in Index (Pearson correlation = 0.378, Sig. = 0.000) and Environmental Awareness (Pearson correlation = 0.398, Sig. = 0.000), implying that increased exposure to educational campaigns and publicity can influence both the awareness of carbon lock-in and environmental issues.

Acceptance of Low-Carbon Transition exhibits a moderate positive correlation with Awareness of Environmental Awareness (Pearson correlation = 0.467, Sig. = 0.000), and Publicity and Education (Pearson correlation = 0.405, Sig. = 0.000), showing that increased awareness and education about environmental issues and low-carbon products significantly enhance consumer acceptance of low-carbon transitions.

4.1.4 Inferential Analysis for Hypothesis Test

In the previous section, Pearson correlation analysis was used to verify the relationships between various factors, which provided a preliminary understanding of the direction, strength, and nature of these relationships. This section used SPSS linear regression analysis to further validate the conceptual framework introduced in Chapter 2. The purpose is to explore the extent to which each influencing factor affects consumers' willingness to purchase carbon-neutral products, and to determine their explanatory power in relation to purchase intention. The analysis also helps identify the key factors influencing consumer purchase behavior regarding carbon-neutral products.

4.1.4.1 Test Result of Research Hypothesis 1

This section tests Hypothesis H1, which proposes that there is a significant relationship between the carbon lock-in index and consumers' acceptance of low-carbon transition. In this regression model, consumers' acceptance of low-carbon transition is set as the dependent variable, while the carbon lock-in index serves as the independent variable. This analysis aims to determine whether the degree of carbon lock-in significantly influences consumers' willingness to adopt and support low-carbon transition initiatives.

Table 4.4 Linear Regression Analysis of Carbon Lock-in Index

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R	R Square	Adjusted R Square	Sample Size (N)
	B	Std. Error	Beta						
(Constant)	12.116	0.944		12.832	0.000	0.390	0.152	0.150	385
Carbon Lock-in Index	0.389	0.047	0.390	8.286	0.000				

As shown in Table 4.4, at the 95% confidence level, the Adjusted R Square is 0.150, indicating that the Carbon Lock-in Index accounts for approximately 15.0% of the variation in Acceptance of Low-Carbon Transition. The R Square value is 0.152, which demonstrates that the overall model explains 15.2% of the variance in the dependent variable.

The regression model is statistically significant, as shown by the significance level of 0.000, which is less than 0.05, supporting the validity of the model. The regression coefficient (B) for Carbon Lock-in Index is 0.389, with a t-value of 8.286 and a p-value of 0.000. This result confirms that there is a significant and positive linear relationship between Carbon Lock-in Index and Acceptance of Low-Carbon Transition.

Therefore, Hypothesis 1 (H1) is supported.

Based on the unstandardized coefficients, the regression equation for this model is:

Acceptance of Low-Carbon Transition = 12.116 + 0.389 × Carbon Lock-in Index

This equation indicates that for each one-unit increase in the Carbon Lock-in Index, the acceptance level of low-carbon transition is expected to increase by 0.389 units, holding all else constant.

4.1.4.2 Test Result of Research Hypothesis 2

This section tests Hypothesis H2, which proposes that there is a significant relationship between consumers' environmental awareness and their acceptance of low-carbon transition. In this regression model, consumers' acceptance of low-carbon transition is set as the dependent variable, while environmental awareness serves as the independent variable. This analysis examines whether consumers with higher levels of environmental awareness are more likely to accept and support low-carbon transition initiatives.

Table 4.5 Linear Regression Analysis of Environmental Awareness

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R	R Square	Adjusted R Square	Sample Size (N)
	B	Std. Error	Beta						
(Constant)	12.915	0.887	—	14.555	0.000	0.375	0.141	0.139	385
Environmental Awareness	0.356	0.045	.375	7.923	0.000				

As shown in Table 4.5, at the 95% confidence level, the Adjusted R Square is 0.139, indicating that the independent variable explains 13.9% of the variation in acceptance of low-carbon transition. The R Square value is 0.141, showing that the overall model accounts for 14.1% of the total variance in the dependent variable.

The model is statistically significant, as indicated by a p-value of 0.000, which is less than 0.05. This suggests that the regression equation is valid and that environmental awareness significantly contributes to predicting the acceptance of low-carbon transition ($\beta = 0.375$, $t = 7.923$, $p < 0.001$). Therefore, Hypothesis 2 (H2) is supported.

4.1.4.3 Test Result of Research Hypothesis 3

This section tests Hypothesis H3, which proposes that there is a significant relationship between demographic factors and consumers' acceptance of low-carbon transition. To examine this relationship, two statistical methods were employed: the independent samples t-test and one-way ANOVA. The t-test was used to compare mean differences in acceptance levels across two-group variables, specifically Gender and Marital Status, while one-way ANOVA was applied to analyze differences across multiple groups for variables including age, education, occupation, and monthly Income.

By applying these methods, the analysis aims to determine whether consumers' acceptance of low-carbon transition varies significantly based on their individual characteristics. The results contribute to understanding how demographic factors influence low-carbon behavior and provide a foundation for identifying target groups in low-carbon policy implementation, communication, and environmental education campaigns.

1) Independent Samples T-Test

Table 4.6 Independent Samples T-Test for Demographic Variables and Acceptance of Low-Carbon Transition

Variable	Variance Assumption	Levene's F	Sig. (F)	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Age	Equal variances assumed	4.46	0.04	1.24	383	0.22	0.56	0.45
	Equal variances not assumed	—	—	1.24	372.14	0.22	0.56	0.45
Marital Status	Equal variances assumed	0.33	0.57	-0.36	383	0.72	-0.17	0.48
	Equal variances not assumed	—	—	-0.35	249.04	0.73	-0.17	0.48

To examine whether age and marital status influence consumers' acceptance of low-carbon transition, an independent samples t-test was conducted.

For the age variable, Levene's test shows a significance value of 0.04, which is less than 0.05, indicating that the assumption of equal variances is not met. Referring to the row "equal variances not assumed," the t-value is 1.24, with a p-value of 0.22. Since the significance level is greater than 0.05, the result indicates that there is no statistically significant difference in acceptance levels between the two age groups.

For marital status, Levene's test returns a significance value of 0.57, indicating that the assumption of equal variances is satisfied. The t-test under this assumption shows a t-value of -0.36, with a p-value of 0.72. As this value is also greater than 0.05, it suggests that there is no significant difference in low-carbon transition acceptance between married and unmarried individuals.

In conclusion, the findings reveal that neither age nor marital status has a statistically significant impact on consumers' acceptance of low-carbon transition. This suggests that environmental awareness and attitudes toward sustainable behavior are relatively consistent across different age groups and marital conditions, possibly due to the widespread dissemination of environmental education and media coverage of climate change issues.

2) One-Way ANOVA Analysis

To investigate whether age, education level, occupation, and monthly income have significant effects on Acceptance of low-carbon transition, a one-way ANOVA test was conducted for each of these variables. The analysis results are presented in Table 4.7.

Table 4.7 One-Way ANOVA for Demographic Variables and Acceptance of Low-Carbon Transition

Source	Sum of Squares	df	Mean Square	F	Sig.
Age					
Between Groups	73.241	4	18.310	0.943	0.439
Within Groups	7379.320	380	19.419		
Total	7452.561	384			
Education					
Between Groups	37.940	4	9.485	0.486	0.746
Within Groups	7414.621	380	19.512		
Total	7452.561	384			

Source	Sum of Squares	df	Mean Square	F	Sig.
Occupation					
Between Groups	146.000	6	24.333	1.259	0.276
Within Groups	7306.561	378	19.330		
Total	7452.561	384			
Monthly Income					
Between Groups	138.574	5	27.715	1.436	0.210
Within Groups	7313.987	379	19.298		
Total	7452.561	384			

In this study, age is divided into five categories: "18–25 years old," "26–35 years old," "36–45 years old," "46–55 years old," and "56 years and above." Therefore, a one-way ANOVA was used to examine whether there are significant differences in Acceptance of Low-Carbon Transition across age groups. As shown in Table 4.9, the significance level is 0.439 > 0.05, indicating that there are no statistically significant differences in acceptance based on age.

For education level, respondents are classified into four groups: "High school or below," "Associate degree," "Bachelor's degree," and "Master's degree or above." A one-way ANOVA analysis shows a significance level of 0.746 > 0.05, suggesting that there is no significant difference in acceptance of low-carbon transition among different education levels.

The occupation variable includes six categories: student, corporate employee, freelancer, government/public institution staff, private sector employee, and others (e.g., self-employed). The ANOVA result shows a significance level of 0.276 > 0.05, indicating that there is no significant difference in low-carbon transition acceptance across occupational groups.

Regarding monthly income, the data are categorized into six levels, ranging from "Below 2,000 RMB" to "Above 17,000 RMB." The one-way ANOVA result reveals a significance level of 0.210 > 0.05, which also indicates no statistically significant difference in acceptance across different income levels.

In conclusion, the results of the one-way ANOVA suggest that none of the four tested demographic variables—age, education level, occupation, and monthly income—exhibit statistically significant differences in influencing consumers'

Acceptance of Low-Carbon Transition. This implies a generally consistent level of acceptance across different demographic segments in the sample.

4.1.4.4 Test Result of Research Hypothesis 4

This section tests Hypothesis H4, which posits that there is a significant relationship between publicity and education and consumers' acceptance of low-carbon transition. In this regression model, consumers' acceptance of low-carbon transition is designated as the dependent variable, while publicity and education serve as the independent variable. This analysis examines whether greater exposure to publicity and educational initiatives contributes to higher levels of consumer acceptance toward low-carbon transition practices.

Table 4.8 Linear Regression Analysis of Publicity and Education

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R	R Square	Adjusted R Square	Sample Size (N)
	B	Std. Error	Beta						
(Constant)	13.291	0.773	—	17.197	0.000	0.405	0.164	0.162	385
Publicity and Education	0.578	0.067	0.405	8.666	0.000				

As shown in Table 4.8, at the 95% confidence level, the Adjusted R Square is 0.162, indicating that Publicity and Education explains approximately 16.2% of the variation in Acceptance of Low-Carbon Transition. The R Square value is 0.164, meaning the model accounts for 16.4% of the total variance in the dependent variable.

The regression model is statistically significant, as shown by a p-value of 0.000, which is less than 0.05, supporting the validity of the model and confirming that Hypothesis 4 (H4) is supported.

The unstandardized coefficient (B) for Publicity and Education is 0.578, with a t-value of 8.666 and a p-value of 0.000, indicating a significant and positive effect on Acceptance of Low-Carbon Transition. This suggests that greater exposure to environmental education and publicity significantly increases public willingness to support low-carbon initiatives.

Based on the unstandardized coefficients, the regression equation for Hypothesis 4 is:

Acceptance of Low-Carbon Transition = 13.291 + 0.578 × Publicity and Education

4.2 Discussion

4.2.1 Impact of Carbon Lock-In on Acceptance of Low-Carbon Transition

The results from this study demonstrate a statistically significant and positive relationship between the Carbon Lock-in Index and the Acceptance of Low-Carbon Transition. This finding is aligned with prior research by Chen et al. (2023), who emphasized that high carbon lock-in levels in urban systems tend to inhibit transitions toward sustainable practices. Similarly, Dong et al. (2023) concluded that smart transportation systems can reduce carbon lock-in, indirectly improving public engagement with low-carbon transitions. The regression analysis in this study, however, suggests that even in urban contexts with measurable carbon inertia, individual acceptance of low-carbon policies can be enhanced through informed awareness, suggesting a more optimistic interpretation than earlier studies.

Contrary to studies that depict carbon lock-in as an overwhelmingly negative structural constraint (Felkner et al., 2024), the findings here imply that increased awareness and targeted interventions may mediate its effects. In particular, this study points to the potential for consumer-level behavioral change despite the presence of systemic lock-in, highlighting the role of psychological and perceptual shifts as mediators of structural limitations.

4.2.2 Role of Environmental Awareness

Environmental awareness emerged as a significant predictor of public acceptance of low-carbon transition, consistent with findings by Duan et al. (2023), who found that informed consumers were more likely to choose carbon-labeled products. The current results reinforce the notion that targeted environmental knowledge and awareness campaigns contribute to shaping sustainable behavior.

However, unlike some previous works that found only indirect effects of environmental concern on behavior (Gansser & Reich, 2023), this study affirms a more direct influence of both environmental and product awareness on willingness to embrace low-carbon lifestyles. This divergence may be attributed to the younger demographic of respondents, who are typically more informed and proactive in seeking sustainability information.

4.2.3 Influence of Publicity and Education

This study finds that publicity and education significantly enhance the acceptance of low-carbon transition, consistent with results from Seto et al. (2021), who argued that policy visibility and public awareness play a pivotal role in shaping environmental behavior. This is also supported by the findings of Wang et al. (2024), who emphasized that public education and consistent environmental messaging can significantly shift individual attitudes.

Nevertheless, some prior studies have noted that the influence of publicity may be overstated if not matched by systemic incentives or infrastructures (Wang et al., 2024). The current findings suggest that while publicity alone may not suffice to induce behavior change, it remains a necessary foundation upon which more comprehensive engagement strategies must be built.

4.2.4 Demographic Differences in Acceptance of Low-Carbon Transition

Interestingly, the study revealed only limited demographic differences in acceptance levels of low-carbon transition. While marital status demonstrated some significance, age, education, occupation, and income did not show statistically significant differences. These findings align with Seto et al. (2021), who suggested that demographic indicators are becoming less predictive of environmental behavior in the context of increasing societal awareness. This suggests that policy and educational interventions may be broadly effective across diverse demographic groups, reducing the necessity for highly segmented approaches.

In summary, this study affirms that awareness-related variables, namely carbon lock-in perception, environmental knowledge, and familiarity with carbon-neutral products, together with educational outreach, significantly shape public acceptance of low-carbon initiatives. These findings support the integration of Path Dependence Theory and Theory of Planned Behavior as the theoretical foundation for analyzing both systemic constraints and individual behavioral intentions in the context of low-carbon transition.

While Path Dependence Theory explains the structural inertia that can hinder behavioral change, Theory of Planned Behavior provides insight into the attitudinal, normative, and control beliefs that influence individuals' willingness to support low-carbon efforts. The unique contribution of this study lies in confirming that despite the presence of structural barriers such as carbon lock-in, well-informed awareness and targeted educational strategies can still promote positive behavioral responses. These results offer actionable implications for policymakers and communicators seeking to design inclusive, multi-level interventions to accelerate public engagement with sustainability.

Chapter 5 Conclusion and Recommendation

5.1 Conclusion

Statement of the Objectives

This study aimed to explore how carbon lock-in, environmental awareness, and publicity and education influence public acceptance of low-carbon transition, specifically within the context of Beijing residents. The objective was to examine both structural constraints and psychological drivers behind individuals' willingness to support low-carbon initiatives, thereby offering theoretical and empirical insights for sustainable policy development.

Summary of Methodology

A quantitative research method was employed in this study. Data were collected through a structured questionnaire distributed to residents in Beijing, with a total of 385 valid responses obtained. The questionnaire measured four main constructs: carbon lock-in index, environmental awareness, publicity and education, and acceptance of low-carbon transition. The collected data were analyzed using descriptive statistics, Pearson correlation, and multiple regression analysis to determine the relationships among variables.

Summary of the Results

The analysis results showed that all four independent variables—carbon lock-in index, environmental awareness, and publicity and education—had significant positive effects on the acceptance of low-carbon transition. Among them, environmental awareness and publicity and education demonstrated the strongest impacts, while carbon lock-in index and product awareness also contributed meaningfully to the variance in acceptance levels.

Key Findings

Key findings from the study include the identification of environmental awareness as the most influential factor in promoting acceptance, highlighting the importance of improving the public's understanding of environmental issues. Publicity and education were also found to significantly shape attitudes, confirming the role of targeted information campaigns in encouraging low-carbon behavior. Awareness of carbon-neutral products showed a positive effect, suggesting that informed consumers are more likely to support green consumption. Finally, the impact of carbon lock-in, though moderate, indicates that structural constraints can still influence public perception when effectively communicated. Overall, the study underscores that both systemic and cognitive factors need to be addressed to enhance public engagement with low-carbon transitions.

5.2 Recommendation

1. Strengthen Environmental Education and Publicity Campaigns

To improve public acceptance of low-carbon transition, it is essential to enhance targeted environmental education and outreach efforts. Publicity campaigns should be designed to clearly explain the importance of carbon neutrality and the benefits of adopting low-carbon lifestyles. These efforts can be carried out through various platforms including schools, community centers, media, and social networks. Clear, relatable messages and compelling case studies will help transform environmental knowledge into active support for low-carbon initiatives.

2. Increase Public Awareness of Carbon-Neutral Products

Government agencies, enterprises, and NGOs should work collaboratively to promote the concept of carbon-neutral products. By organizing public exhibitions, pilot programs, and labeling initiatives, consumers can be made more familiar with low-carbon alternatives in the marketplace. Greater awareness will reduce information asymmetry and help consumers make more environmentally conscious purchasing decisions, thereby fostering broader acceptance of low-carbon consumption patterns.

3. Reduce the Impact of Carbon Lock-In through Systemic Reforms

Although carbon lock-in is often viewed as a structural challenge, its effects can be mitigated through targeted policy and infrastructure changes. Urban planning should prioritize low-carbon infrastructure, renewable energy access, and smart mobility systems. Additionally, policymakers should design incentive mechanisms—such as tax rebates, subsidies, or regulatory support—to encourage both producers and consumers to shift toward low-carbon behaviors, thereby unlocking the system from high-carbon pathways.

4. Leverage Digital Platforms for Low-Carbon Engagement

Digital technologies and social media platforms offer valuable tools for promoting low-carbon awareness and encouraging participation, especially among younger populations. Authorities and brands can launch interactive challenges, digital reward systems, or carbon footprint tracking apps that make low-carbon behavior more engaging. These approaches not only enhance publicity but also create a sense of personal accountability and community belonging around low-carbon action.

5. Develop Targeted Strategies for Demographic Segments

Although this study found limited demographic differences in acceptance levels, minor variations—those related to marital status—suggest that targeted strategies may still be effective. For example, family-based campaigns might resonate more with married individuals, while youth-focused outreach could emphasize career relevance or environmental innovation. Tailoring communication strategies to match the values and habits of different social groups can improve message effectiveness and promote inclusive low-carbon transitions.

5.3 Further Study

Future research may explore how the carbon lock-in phenomenon evolves over time and its long-term impact on public acceptance of low-carbon transitions, particularly in rapidly urbanizing regions. A longitudinal approach could help determine how infrastructure upgrades, policy interventions, or shifts in governance affect perceptions of carbon dependence. Additionally, expanding the research to other cities or provinces beyond Beijing would allow for comparative analysis across different urban governance contexts, providing insights into regional variations in low-carbon transition readiness.

Moreover, future studies should consider incorporating qualitative methods, such as in-depth interviews or focus groups, to better understand the psychological and behavioral mechanisms that underlie low-carbon transition acceptance. This would enrich the findings by capturing nuanced perspectives that quantitative surveys might overlook. Researchers may also investigate the role of digital media and environmental campaigns in shaping public awareness and engagement with carbon-neutral products, as well as how such efforts interact with structural barriers like carbon lock-in. Cross-cultural or international comparative studies could further reveal whether the observed patterns hold across different socio-political environments, enhancing the generalizability of the findings.

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Appendix

Dear Participant,

Thank you for taking the time to participate in this survey. This study aims to investigate the factors influencing the acceptance of low-carbon transition among enterprises under the background of China's "Dual Carbon" goals. Specifically, the research focuses on key influencing factors such as the Carbon Lock-in Index, Awareness of Carbon-Neutral Products and Environmental Issues, Publicity and Education, and Demographic Characteristics in the context of Beijing.

This survey is conducted anonymously, and all responses will be used strictly for academic research purposes only. Your personal information will be kept confidential and will not be disclosed to any third parties. The questionnaire is designed to capture your views on low-carbon policies, environmental knowledge, carbon governance, and your support for low-carbon initiatives. The estimated time to complete the survey is approximately 5–10 minutes.

Your honest and thoughtful responses are essential to the success of this research. Please answer all questions based on your actual understanding and experience. We sincerely appreciate your valuable contribution and support. Wishing you a pleasant day.

JIE LIU

Part I: Demographic Characteristics

(Please tick the appropriate box)

1. What is your gender?

A. Male

B. Female

2. What is your age?

A. 18–25 years old

B. 26–35 years old

C. 36–45 years old

D. 46–55 years old

E. 56 years and above

3. What is your marital status?

A. Single

B. Married

4. What is your highest level of education?
A. High school or below
B. Associate degree
C. Bachelor’s degree
D. Master’s degree or above

5. What is your current occupation?
A. Student
B. Corporate employee
C. Freelancer
D. Government employee / Public institution staff
E. Private sector employee
F. Other (e.g., self-employed)

6. What is your monthly income?
A. Below 2,000 RMB
B. 2,000–5,000 RMB
C. 5,000–8,000 RMB
D. 8,000–12,000 RMB
E. 12,000–17,000 RMB
F. Above 17,000 RMB

Please answer the following questions based on your actual understanding and experience.

(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Table A-1 Measurement Items for Carbon Lock-In Index

Digital Resources (DR)	1	2	3	4	5
CLI1. I believe that a shift toward low-carbon production models (e.g., using renewable energy) can significantly improve the environment.	1	2	3	4	5
CLI2. I believe that efforts by enterprises to reduce carbon emissions can enhance their market competitiveness.	1	2	3	4	5
CLI3. I believe that reducing reliance on traditional high-carbon energy sources can increase consumer recognition of the enterprise.	1	2	3	4	5
CLI4. I believe that adopting low-carbon technologies and green production processes can help build public trust in the low-carbon transition.	1	2	3	4	5
CLI5. I believe that breaking away from traditional carbon-intensive development paths through innovation and technological transformation will promote low-carbon transition and attract greater consumer support.	1	2	3	4	5

Table A-2 Measurement Items for Environmental Awareness

Digital Resources (DR)	1	2	3	4	5
EA1. I believe that low-carbon transition by enterprises is crucial for environmental protection and can reduce the negative impacts of carbon emissions.	1	2	3	4	5
EA2. I believe that low-carbon transition by enterprises can not only mitigate climate change but also improve air quality and the ecological environment.	1	2	3	4	5
EA3. I believe that low-carbon production and consumption models can help enterprises reduce resource waste and promote sustainable development.	1	2	3	4	5
EA4. I believe that understanding the significance of low-carbon transition can increase my acceptance of low-carbon products from enterprises.	1	2	3	4	5
EA5. I believe that enterprises' low-carbon transition contributes to ecological protection and promotes green development for the future society.	1	2	3	4	5

Table A-3 Measurement Items for Publicity and Education

Digital Resources (DR)	1	2	3	4	5
PE1. I frequently hear or see publicity related to corporate low-carbon transition.	1	2	3	4	5
PE2. Information obtained from journals, newspapers, and media about policies and technological promotion related to corporate low-carbon transition makes me more willing to support such initiatives and participate in relevant actions.	1	2	3	4	5
PE3. I support the introduction of stronger national policies to encourage both enterprises and individuals to actively participate in the low-carbon transition,	1	2	3	4	5

Digital Resources (DR)	1	2	3	4	5
reduce carbon emissions, and promote the widespread adoption of low-carbon technologies and products.					

Table A-4 Measurement Items for Acceptance of Low-Carbon Transition

Digital Resources (DR)	1	2	3	4	5
ALT1. I am willing to participate in Beijing's low-carbon transition initiatives and adopt a corresponding low-carbon lifestyle.	1	2	3	4	5
ALT2. I support the joint efforts of the government and enterprises in promoting low-carbon policies and technologies to facilitate the transition.	1	2	3	4	5
ALT3. I am willing to pay a higher price for low-carbon products because I believe they are beneficial to the environment.	1	2	3	4	5
ALT4. I am willing to change traditional high-carbon consumption behaviors and support the adoption and application of low-carbon technologies.	1	2	3	4	5
ALT5. I believe that the low-carbon transition is an effective approach to addressing climate change, and I am willing to actively participate in it.	1	2	3	4	5