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EDITED BY
Otilia Manta,
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REVIEWED BY
Claudia Covucci,
Mercatorum University, Italy
Kamal Gnanaweera,
University of Sri Jayewardenepura, Sri Lanka

*CORRESPONDENCE
Junyan Li,
leejy@stu.sufe.edu.cn

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City brand and urban environmental sanitation: evidence from the national civilized city in China

Junyan Li[1]* and Lei Xu [2]

[1]School of Public Economics and Administration, Shanghai University of Finance and Economics, Shanghai, China, [2]School of Economics and Trade, Hunan University of Technology and Business, Changsha, Hunan, China

Introduction: With rapid urbanization and rising living standards, environmental sanitation management has emerged as a critical component of modern urban governance systems. Concurrently, urban brand has gained prominence as a key indicator of a city's soft power in contemporary urban development studies.

Methods: Based on panel data from 285 prefecture-level cities during 2001-2023, this study employs the acquisition of the National Civilized City (NCC) brand as a quasi-natural experiment and utilizes a difference-in-differences (DID) approach, with municipal solid waste collection and treatment as metrics for urban environmental sanitation, to investigate the impact and underlying mechanisms of city brand on environmental sanitation.

Results: The findings reveal that: First, cities that achieved the NCC brand demonstrated significant improvements in environmental sanitation metrics, including increased municipal solid waste collection volume, harmless treatment volume, harmless treatment rate, and harmless treatment capacity. This improvement does not stem from short-term behaviors during the NCC evaluation period, but rather persists after obtaining the brand certification. Second, our mechanism analysis reveals that the NCC brand enhances urban environmental sanitation through three channels: improved sanitation infrastructure, increased governmental environmental attention, and heightened public environmental attention. Third, our heterogeneity analysis shows that the environmental impact varies across different urban contexts, with stronger effects observed in ordinary cities compared to higher-tier administrative centers, and more pronounced improvements in cities outside urban agglomerations versus those within urban agglomerations.

Discussion: This study broadens the research scope of city brand and enriches the environmental research framework within the Chinese context, while providing practical insights for policymakers seeking to enhance both city brand development and environmental management efficiency. The study proposes establishing long-term governance mechanisms combined with

dynamic monitoring systems and adopting a multi-stakeholder co-governance model. Furthermore, it recommends implementing differentiated environmental strategies tailored to urban development levels.

KEYWORDS

city brand, national civilized cities, environmental sanitation, municipal solid waste, difference-in-differences

1 Introduction

Urban marketing emerged from a paradigmatic shift from traditional administrative approaches to urban entrepreneurialism, wherein local governments increasingly adopt corporate operational strategies and embed speculative management techniques within urban governance frameworks, akin to entrepreneurial product development and promotional methodologies (Harvey, 1989; Eshuis and Edwards, 2013). As urbanization advances and global inter-city competition intensifies, city brand has become a crucial strategic tool for competing for high-quality resources and promoting sustainable urban development (Anttiroiko, 2015). According to place branding theory by Kavaratzis and Ashworth (2006), urban branding fundamentally represents a strategic brand identity construction process. This process integrates strategic planning, stakeholder consensus, and core values to articulate a distinctive urban positioning. Analogous to how corporate brand value influences market performance through consumer perception and commitment (Behrens et al., 2014), urban branding necessitates translating brand value into concrete policy actions through sophisticated governance mechanisms to enhance overall urban competitiveness.

Prior scholarship traditionally conceptualized branding as an ultimate objective, positing that successful brand construction inherently signifies performance achievement. However, recent research underscores the substantive significance of branding for local governance activities (Eshuis and Erik-Hans, 2012). Governments worldwide have increasingly integrated branding strategies into governance processes, with brands assuming critical roles in organizational management and political operations (Zavattaro et al., 2021). For local governments, urban branding transcends mere symbolic representation, emerging as a pivotal mechanism for constructing regional identity and image, ultimately reshaping public perception to catalyze comprehensive development (Eshuis and Erik-Hans, 2012). Local governments recognize the significance of brand value in urban development and have implemented various initiatives to build city brands, enhancing their attractiveness and competitiveness (Torres and Godinho, 2020; Ewelina et al., 2022). From a practical perspective, city brand building primarily follows two paths. The first is bottom-up brand creation, where cities leverage their unique characteristics and advantages through hosting international events, developing cultural IP, and fostering distinctive industries to gradually build unique urban images and brand value (Ma et al., 2020; Li J. et al., 2022). Its essence is to strengthen the functional attributes and symbolic value of a city through "Brand Positioning" (Kavaratzis and Ashworth, 2006). The second is top-down brand certification, which involves participating in national-level evaluation and certification systems to obtain officially recognized urban honors. In recent years, nationwide selection programs for National Civilized Cities (NCC), Low-Carbon Cities, Innovation Cities, and Smart Cities exemplify this approach (Cao et al., 2025; Yang et al., 2024; Hou and Shi, 2024; Liu et al., 2024). This certification embodies a corporate branding governance approach that strategically establishes a unified evaluation framework and core value standards, effectively orchestrating multi-stakeholder actions to advance urban governance objectives (Kavaratzis and Ashworth, 2006). Among these, the NCC title is regarded as the highest comprehensive honorary brand for cities, reflecting the overall development level and civilization standards of Chinese cities (Guo et al., 2024; Han et al., 2023; Li B. et al., 2022; Li D. et al., 2022).

Institutional isomorphism theory within neoinstitutionalism posits that organizations operating within similar institutional environments tend to converge structurally and behaviorally (Dacin et al., 2002; DiMaggio and Powell, 1983). This perspective suggests that individuals and organizations seek legitimacy by adhering to specific institutional norms and rules (George et al., 2020; Meyer and Rowan, 1977). Extant research has consistently demonstrated that institutional pressures serve as critical drivers of governmental environmental initiatives (Chen X. H. et al., 2018; Dubey et al., 2015; Ilg, 2019; Dangelico, 2016). City branding emerges as a potent form of institutional pressure, shaped by diverse stakeholders including governmental bodies, competitive entities, and public constituencies (Zhang et al., 2019). Through legitimacy mechanisms, city branding effectively motivates local governmental environmental governance strategies and interventions (Mitchell et al., 2022; Zhou et al., 2021). The proliferation of social media has catalyzed urban branding, which in turn shapes regional reputation formation (Bankins and Waterhouse, 2019). Through reputation mechanisms, urban reputation exerts a significant positive influence on economic activities (Delgado-Garcia et al., 2018; Torres and Godinho, 2020). While branding generates resource benefits, it simultaneously introduces reputational pressures (Hall, 2021). When a brand fails to meet societal expectations, it potentially triggers public scrutiny of administrative legitimacy and performance evaluation by higher-level governmental authorities. Consequently, governments are compelled to engage in strategic reputation management, which consequently motivates local authorities to implement more rigorous environmental governance policies (Bustos, 2021; Rimkutė, 2018; Bankins and Waterhouse, 2019). Empirical evidence supports this mechanism, as Liu et al. (2023) demonstrated that urban branding significantly promotes urban green development through industrial structural upgrading and technological advancement.

Good environmental sanitation serves as a fundamental guarantee for urban development. As urbanization accelerates

and living standards improve, urban environmental sanitation management has become a core component of modern city construction. However, numerous challenges persist in current urban environmental sanitation. From a governance perspective, there are issues with inadequate government oversight, unclear departmental responsibilities, and insufficient public participation. In terms of management approaches, problems include outdated technology, inadequate funding, and extensive rather than intensive management methods. Regarding outcomes, there remains a significant gap between the current level of urban sanitation and public expectations. The challenges are particularly prominent in solid waste management. With rapid economic growth, urban population concentration, and accelerated pace of urban life, municipal solid waste is characterized by "high volume, mixed composition, and processing difficulties." Many regions face the predicament of being surrounded by waste (Weststrate, 2023; Gao et al., 2023; Kuang and Lin, 2021; Peng et al., 2021).

Historically, Chinese cities employed rudimentary waste management practices, primarily relying on basic landfilling or open dumping. Some cities simply relocated waste from urban centers to suburban areas or disposed of it directly into rivers and lakes (Chien et al., 2021). These disposal methods led to severe environmental consequences. The practice of untreated waste being openly dumped or arbitrarily disposed of not only consumed valuable land resources but also contaminated air and water supplies. More critically, the natural decomposition of waste generates substantial amounts of harmful gases, such as ammonia and hydrogen sulfide, which not only pollute the environment but also pose direct threats to human health (Zoungrana et al., 2024). Research indicates that residents living near landfill sites experience significantly higher rates of respiratory diseases compared to those in more distant areas (An et al., 2022). Consequently, solid waste has emerged as another major environmental challenge, following air and water pollution (Liu et al., 2023; Britta et al., 2024).

From a brand governance perspective, if cities merely conceptualize brand as a superficial image project, rather than embedding it deeply within governance logic, meaningful environmental sanitation improvements remain elusive (Kavaratzis and Ashworth, 2006). China's environmental policies have been misaligned with local government development incentives, characterized by systematic data manipulation, overly rigid enforcement, and performative bureaucratic approaches. Consequently, the central government has implemented a series of environmental assessment policies. However, these policies exhibit critical limitations. Local authorities predominantly prioritize targeted pollutant reduction over comprehensive environmental improvement, with urban sanitation being a particularly neglected dimension. China's urban sanitation system has relied on local fiscal allocations as its primary funding mechanism. However, regional authorities consistently prioritize economic development over environmental hygiene management budgeting. Typically, the allocated budget for environmental sanitation management falls significantly short of operational requirements, particularly in economically underdeveloped regions characterized by limited infrastructure investment and substantial fiscal constraints. Despite growing subjective awareness of urban environmental sanitation management's importance, actual resource allocation remains constrained by restrictive fiscal budgets. Consequently, resources are strategically channeled toward sectors promising maximal economic returns, leaving insufficient funds for environmental infrastructure development. This funding paradigm effectively marginalizes urban sanitation management, rendering its practical implementation critically undervalued.

Existing urban brand literature predominantly focuses on two critical dimensions. First, scholars have employed normative analysis to substantiate the theoretical legitimacy and practical significance of urban brand, critically examining its inherent challenges (Belabas, 2023; Green et al., 2016). Second, recent quantitative research has increasingly leveraged causal inference methods to explore urban brand policy effects, predominantly concentrating on socioeconomic outcomes (Pope and Kim, 2022; Chai et al., 2022; Li Q. et al., 2024).

While existing literature has made valuable contributions to exploring the environmental governance effects of NCC brand, significant research gaps persist regarding its impact on environmental sanitation and underlying mechanisms. First, prior research has predominantly concentrated on explicit environmental indicators such as air pollution and industrial emissions (Liu et al., 2023; Yu et al., 2023), overlooking environmental sanitation-a critical domain directly affecting residents' quality of life. At the solid waste management level, extant studies have primarily focused on technical processing approaches (Afsana et al., 2025), without systematically examining policy-driven institutional improvement mechanisms. Second, the underlying causal logic through which NCC brand operates as an innovative governance tool, particularly its impact on environmental sanitation *via* institutional pressures and signaling mechanisms, has not been comprehensively elucidated. Third, existing literature predominantly examines selection effects from a narrowly instrumental perspective of cities competing for the NCC title. Critically, this approach overlooks a crucial nuance: selection effects inherently materialize before official designation, whereas DID method typically assess post-designation outcomes. Consequently, such approaches inadvertently conflate distinct conceptual domains-selection effects and brand incentive mechanisms-thereby obscuring the subtle yet consequential differences between these analytical constructs.

Based on the foregoing discussion, this paper raises several key questions for further investigation: First, Can the NCC brand effectively improve urban environmental sanitation? Second, Through which mechanisms does the NCC brand influence urban environmental sanitation? Third, Is there heterogeneity in the impact of the NCC brand on urban environmental sanitation across different cities? This study utilizes panel data from 285 prefecture-level cities in China spanning 2001 to 2023 and employs a multi-period difference-in-differences (DID) method to investigate these issues. This method serves as an effective empirical approach for evaluating policy effects, with extensive applications in urban policy research (Liu et al., 2023; Xu et al., 2025). The NCC designation exhibits quasi-random characteristics, with its multidimensional selection criteria spanning economic, social, and environmental domains, wherein environmental sanitation represents a marginal component. This nuanced feature renders the NCC designation amenable to treatment as an exogenous shock, satisfying the DID method's prerequisite of pre-intervention

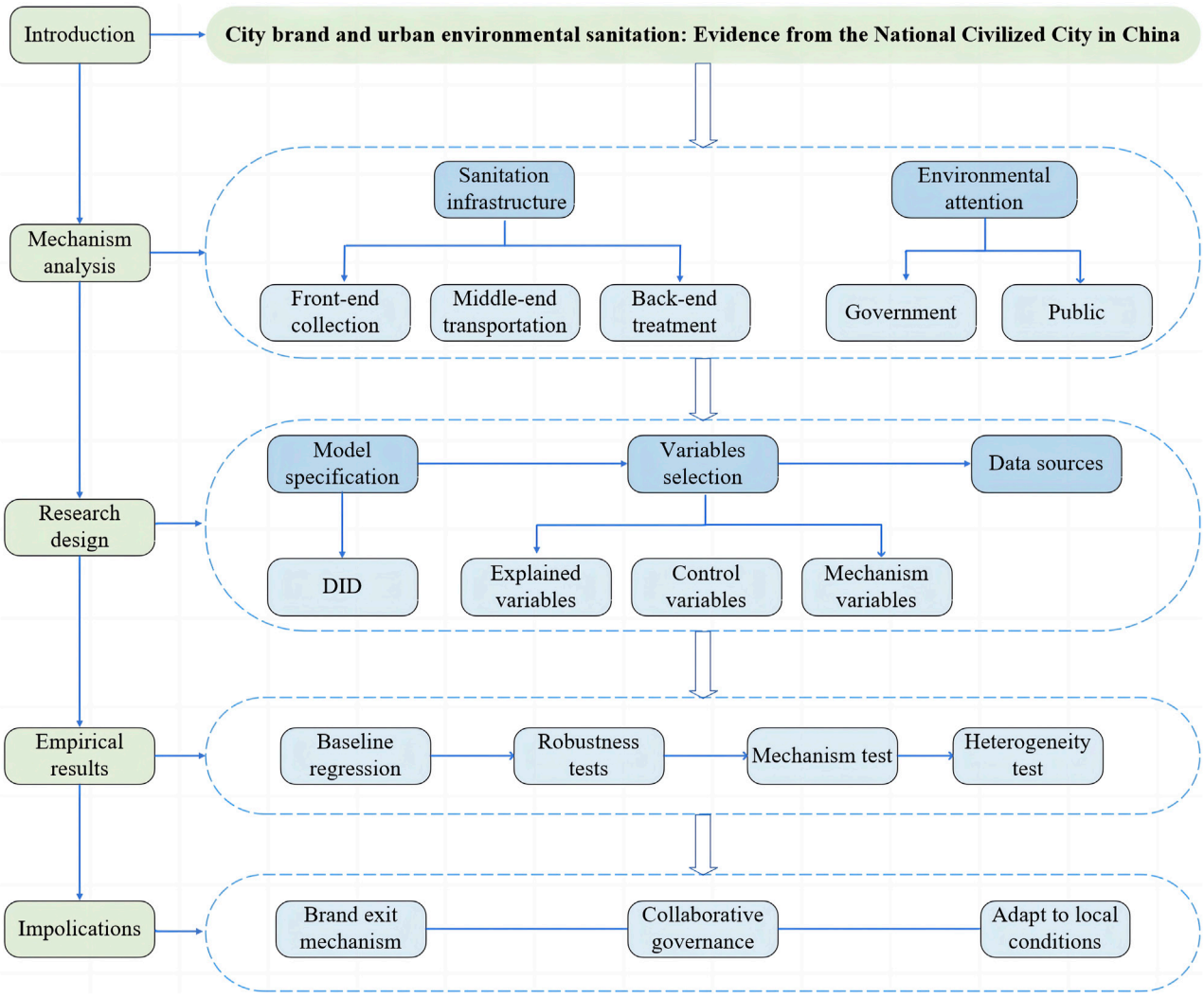

FIGURE 1
Framework structure diagram.

comparability between treatment and control groups. Unlike uniform policy interventions, the NCC designation follows a staggered implementation, with cities receiving certification at disparate time points. Consequently, a multi-period DID approach, through flexible treatment-time dummy variables, enables precise estimation of policy impacts. By exploring how city brand effects improve urban environmental sanitation, this study provides the latest evidence from China, aiming to offer valuable references for other countries in creating healthy and comfortable living environments and promoting sustainable urban development.

This study offers several potential marginal contributions: First, in recent years, the central government has implemented various environmental regulatory measures to address environmental challenges. While academic research on environmental pollution control remains active, studies have primarily focused on water quality, air quality, and pollutant emissions (Du et al., 2022; Liu et al., 2025; Lin, 2025; Ou et al., 2024), with relatively insufficient attention paid to solid waste as a critical environmental issue. By adopting a new perspective on urban environmental sanitation, this study not only broadens the analytical scope of NCC brand effects but also enriches the environmental research framework within the Chinese context from a policy perspective. Second, as China's most valuable urban brand, the implementation effectiveness of the NCC program has consistently been a focus of academic attention. Unlike previous studies that examined NCC implementation effects primarily from economic and public service perspectives (Zhang C. et al., 2021; Liu et al., 2023), this study specifically investigates the impact of NCC brand effects on urban environmental sanitation, representing a significant complement to existing literature. Third, regarding methodology, this study treats NCC brand acquisition as a quasi-natural experiment, employing a multi-period DID approach to evaluate urban environmental sanitation. This method better mitigates potential endogeneity issues and enhances the reliability of research findings.

The remainder of this paper is structured as follows: Section 2 presents the research hypotheses developed based on relevant

literature. Section 3 describes the research design, including model specification, variable selection, and data sources. Section 4 presents the empirical analysis, showcasing the main findings and robustness tests. Section 5 provides further analysis, exploring the influence mechanisms and heterogeneity analysis. Section 6 concludes with a summary of findings, policy implications, and directions for future research.

2 Research hypotheses

In this section, we examine the impact and mechanisms of NCC brand on urban environmental sanitation and propose our research hypotheses. Figure 1 illustrates the framework structure of this article, and the following are our research hypotheses.

DiMaggio and Powell (1983) conceptualized institutional pressures through three distinct mechanisms: coercive, mimetic, and normative pressures. Coercive pressures primarily emerge from formal and informal institutional constraints imposed by organizations upon which an entity depends. For the NCC brand, coercive institutional pressures are predominantly manifested through regulatory constraints imposed by central government authorities (Liang et al., 2007). The NCC designation stands as a prestigious recognition of a city's comprehensive strength and development achievements (Liu et al., 2023; Cui et al., 2024). However, this coveted designation is not merely a one-time accolade but demands rigorous and continuous maintenance efforts. From a brand maintenance pressure perspective, cities face the real risk of losing their NCC status if they experience significant safety incidents, environmental pollution events, or other adverse circumstances that compromise their standing (Li X. M. et al., 2024). Notably, the pressure to maintain this designation often proves more intense and demanding than the initial effort to obtain it, therefore cities must work diligently to preserve this hard-won honor by placing heightened emphasis on environmental sanitation and urban management practices (Han et al., 2022; Jiang et al., 2024).

Mimetic pressures emerge from organizational observations and emulation of peer practices, particularly in contexts of uncertainty. Organizations tend to mimic their peers as a cost-effective strategy for obtaining reliable problem-solving approaches, whereby peer dynamics constitute the primary mechanism of mimetic institutional pressure. In environmental sanitation governance, cities that initially secured the NCC brand generated exemplary effects through government documents and media channels, thereby motivating subsequently branded cities to proactively emulate their environmental management models (George et al., 2020). For pioneering NCC brand cities, to maintain their exemplary status and continue serving as role models for other cities, they establish robust and comprehensive sanitation systems, supported by sustainable funding mechanisms. This transformation fundamentally shifts the approach to urban sanitation from temporary or periodic initiatives to systematic, routine operations. Such institutionalization ensures the long-term maintenance of urban appearance, environmental quality, and public health standards.

Normative pressures emanate from professionalization processes, arising from societal norms, institutional expectations, and regulatory bodies that exert institutional constraints on organizations. Governmental entities must continuously align their strategies with evolving societal expectations. Upon obtaining a NCC brand designation, media proliferation significantly amplifies public environmental quality expectations, thereby constructing a robust social surveillance mechanism (Scott, 2001). This pressure transmission pathway effectively transforms sporadic environmental remediation efforts into systematized, institutionalized management protocols. Based on these arguments, we propose the following hypothesis:

Hypothesis 1: The NCC brand improves urban environmental sanitation through the combined effects of coercive, mimetic, and normative pressures.

According to signaling theory, brands can effectively transmit valuable information (Erdem and Swait, 1998). From an information economics perspective, Erdem and Swait (2016) articulated two primary brand functions: first, brands facilitate information dissemination while reducing transaction costs and mitigating information uncertainty, thereby enhancing consumers' product and quality perceptions; second, brands serve as symbolic entities that evoke emotional and experiential associations, thereby increasing product identification. City brand operates as a signal reflecting urban intrinsic characteristics and external manifestations. Compared to locally initiated branding efforts, the NCC brand-awarded by the Central Civilization Committee-possesses distinct signaling advantages. Its superior institutional origin, comprehensive evaluation scope, and rigorous selection criteria signify a definitive validation of urban cultural appeal and governance effectiveness (Connelly, 2011). This prestigious certification enables cities to communicate their fundamental essence, substantially enhancing regional visibility and legitimacy. Media engagement plays a critical intermediary role in brand signal transmission. Sustained and extensive media coverage not only amplifies the NCC brand's prominence but also generates "reputation maintenance pressure" through social surveillance mechanisms (Laroche et al., 2012). To sustain their hard-earned reputation, local governments strategically leverage visible environmental sanitation infrastructure investments as credible signals of "continuous compliance" and institutional excellence (Li and Wen, 2023; Ma et al., 2024).

The overall sanitation infrastructure system is made up of three connected components: Front-end collection, middle-end transportation, and back-end treatment facilities. Front-end improvements include stepped-up street cleaning operations, broader service coverage areas, and upgraded mechanization of household waste collection processes. Middle-end improvements mainly focus on expanding the specialized sanitation truck fleet to enhance waste transfer capacity and operational efficiency. Back-end improvement focuses on constructing or expanding waste treatment facilities to improve harmless waste processing capacity. These hardware components form a comprehensive infrastructure chain from collection through transportation to processing, ultimately resulting in superior waste management capabilities that distinguish NCC cities from their non-NCC counterparts. Thereby, we propose the following hypothesis:

Hypothesis 2: The NCC brand improves urban environmental sanitation improvement by increasing investment in sanitation infrastructure.

According to attention-based theory (Simon and March, 1957), decision-making agents exhibit significant heterogeneity in their attentional patterns across different domains. This theoretical framework conceptualizes attention as the systematic allocation of temporal, cognitive, and material resources by agents to specific domains and issues, which manifests in focused resource deployment activities. The theory emphasizes that attention is a scarce resource, and how organizations distribute this resource significantly influences their strategic choices and operational outcomes. Government attention reflects the degree of importance that government departments attribute to specific information or issues. When a government department directs its attention to a particular issue, it signals that the issue has gained governmental recognition and policy action is imminent (Li Q. et al., 2024). This focused attention typically translates into concrete policy initiatives and resource allocation decisions. Variations in local governments' attention allocation to environmental governance substantially influence their policy priorities and shape both the direction and intensity of resource allocation in environmental management (Tang et al., 2024; Du et al., 2024).

The attainment of NCC status leads to enhanced governmental environmental attention. This enhancement is primarily driven by the dynamic management mechanism inherent in the NCC program. Unlike other urban accolades, the NCC program implements a stringent dynamic exit mechanism, where cities face the risk of title revocation upon the occurrence of significant negative incidents, including environmental pollution events. For local governments, the political pressure and negative implications associated with losing the NCC status typically exceed the pressure experienced during the initial pursuit of the designation. Environmental quality, serving as a highly visible indicator of urban performance, is particularly susceptible to public and media scrutiny. Consequently, to mitigate the risk of environmental incidents that could precipitate title revocation, local governments elevate their attention to environmental protection, allocating increased administrative resources toward environmental governance. This enhanced governmental environmental attention facilitates continuous improvements in urban environmental sanitation. (Bao and Liu, 2022). Therefore, we propose the following hypothesis:

Hypothesis 3: The NCC brand improves urban environmental sanitation improvement by enhancing government environmental attention.

From a resource-based perspective, public attention represents a scarce cognitive resource. In imperfect markets, limitations in information processing capacity determine the finite nature of public attention, compelling individuals to focus on specific key points that ultimately shape their decision-making behavior (Augerp and Devinney, 2007). This cognitive constraint significantly influences how society processes and responds to various issues, including environmental concerns. With the continuous advancement in living standards and escalating environmental challenges, public environmental consciousness has deepened substantially, leading to heightened recognition of environmental protection's significance (Liu et al., 2019; Bergquist and Warshaw, 2019). Public environmental attention, conceptualized as the degree of willingness to support environmental issue resolution, enables citizens to articulate their environmental demands directly through governmental online platforms. Local governments, operating under performance evaluation pressures, typically respond by implementing relevant measures to address these public demands. Consequently, public environmental attention has emerged as a pivotal force in strengthening environmental protection efforts (Li X. et al., 2022; Liu et al., 2020). Following the acquisition of the NCC brand, cities become exemplary benchmarks, resulting in elevated public expectations regarding urban sanitation quality. The public exercises enhanced oversight and provides feedback on environmental issues through online searches and public opinion channels (Chu et al., 2024; Chen Y. et al., 2023). This intensified public attention generates supervisory pressure on governmental environmental governance, compelling authorities to prioritize and address sanitation issues promptly (Yang et al., 2024; Zhang et al., 2024). Moreover, heightened public attention catalyzes citizens' willingness to participate in sanitation affairs, fostering positive interactions between governmental governance and public participation (Liu et al., 2024; Xu et al., 2024). This collaborative dynamic creates a synergistic relationship between governmental initiatives and community engagement in maintaining urban sanitation standards, ultimately enhancing the effectiveness of environmental governance systems. Therefore, we propose the following hypothesis:

Hypothesis 4: The NCC brand improves urban environmental sanitation improvement by raising public environmental attention.

3 Research design

3.1 Model specification

To substantively enhance residents' wellbeing and cultivate a civilized, livable modern urban environment, the Central Civilization Commission formally initiated the NCC evaluation program nationwide in 2003. The NCC assessment comprehensively evaluates urban development across six critical dimensions: political, economic, cultural, social, ecological civilization, and Party-building domains. Spearheaded by the Central Civilization Committee, this large-scale recognition program is government-led and characterized by nationwide civic participation. The NCC brand, established early with extensive influence, is widely regarded as the most prestigious comprehensive honor for cities, serving as a holistic indicator of urban developmental sophistication and civilizational advancement. Notably, the designation is not a permanent accolade but subject to rigorous ongoing evaluation. Each assessment cycle involves not only awarding new honorary titles but also conducting comprehensive reviews of existing recipients. Cities exhibiting significant deficiencies risk suspension or revocation of their NCC status, thereby compelling municipalities to establish sustainable mechanisms for continuous urban civilization enhancement. The first batch of NCC emerged in October 2005,

with subsequent evaluations conducted triennially. By 2018, six cohorts had been identified, encompassing 106 prefecture-level cities. This longitudinal assessment framework provides an optimal quasi-experimental research design for empirical analysis.

We employ the difference-in-differences (DID) methodology to examine the impact of NCC brand designation on urban environmental sanitation. For group allocation, the cities awarded the NCC brand were designated as the treatment group, while the remaining cities without the NCC brand served as the control group. The NCC brand generates two key sources of variation: within-city temporal variation (comparing pre- and post-brand periods) and cross-sectional variation between NCC-branded and non-NCC cities at any point in time. Our DID regression framework effectively controls for both contemporaneous policy effects and pre-existing differences between branded and non-branded cities, allowing us to isolate the causal effect of NCC brand designation on urban environmental sanitation. Ashenfelter (1978) first introduced the DID method into economic empirical research, with its core method comparing the differences between treatment and control groups before and after policy implementation, constructing policy effect estimators. This method fundamentally addresses endogeneity concerns through a "quasi-experimental" framework, which does not mandate strict random assignment between treatment and control groups. The key assumption of the DID method is the parallel trends assumption, which posits that in the absence of policy intervention, the outcome trajectories of the treatment and control groups would have followed parallel paths. By utilizing dynamic effect testing methods, examining the significance of pre-treatment period coefficients, thereby validating this assumption and enhancing the reliability of causal inference. Recognizing the staggered timing of NCC designations, we adopted a multi-period DID approach, following the methodological approach of Beck et al. (2010) and Almond et al. (2019). We formalize this empirical strategy in Equation (1):

$$Y_{it} = \beta_0 + \beta_1 (D_i \times T_t) + \beta_2 Z_{it} + \mu_i + \eta_t + \varepsilon_{it} \quad (1)$$

The dependent variable Y_{it} measures environmental sanitation in city i at year t. Our key explanatory variable, $D_i \times T_t$, is a binary indicator that takes the value of 1 if city i has received the NCC brand designation in year t, and 0 otherwise. We include a vector of city-year level control variables, Z_{it}, that influence environmental sanitation. The specification incorporates both city fixed effects (μ_i) and time fixed effects (η_t), with ε_{it} denoting the idiosyncratic error term. The coefficient of interest, β_1, measures the causal effect of NCC brand designation on environmental sanitation, where a positive and statistically significant estimate would suggest that the NCC brand effectively improves urban environmental sanitation.

In addition to using cities that did not receive the NCC brand as the control group in the DID method, this paper employs several methods in the robustness analysis section to select new control groups: using Propensity Score Matching (PSM) to select a control group similar to the treatment group on observable variables; removing control groups that border civilized cities.

3.2 Variables selection

3.2.1 Explained variables

Based on previous studies (Ma et al., 2024) and data availability constraints, our analysis employs four explained variables to measure municipal solid waste (MSW) management performance. (1) Collection volume (CV) captures the total MSW collected, measured in ten thousand tonnes. (2) Harmless treatment volume (HTV) represents the quantity of MSW that undergoes harmless treatment processes, also measured in ten thousand tonnes. (3) Harmless treatment rate (HTR) is calculated as the ratio of harmlessly treated MSW to total collected MSW. (4) Harmless treatment capacity (HTC) reflects the daily processing capability for harmless MSW treatment, measured in hundred tonnes per day.

3.2.2 Control variables

To account for potential confounding factors that may influence urban environmental sanitation, we include a comprehensive set of socioeconomic control variables. These controls comprise: (1) Economic development level (PGDP). Economic development is closely related to environmental issues. Many scholars have found that pollutants and economic growth follow an inverted U-shaped curve relationship, which is typically referred to as the Environmental Kuznets Curve (EKC) (Liu X. X. et al., 2022; Zhang M. et al., 2021; Grossman and Krueger, 1995). PGDP is measured by *per capita* GDP in thousand RMB; (2) Urbanization level (UL). Although urbanization has brought significant economic prosperity, it has also caused numerous environmental problems due to increased population density (Wu et al., 2021; Liu H. M. et al., 2022; Ren et al., 2022). UL is defined as the ratio of non-agricultural employment to total population; (3) Road density (RD). The impact of road density on the environment is a complex ecological issue, and numerous scholars have studied their relationship (Meng and Han, 2018; Sugar et al., 2012; Shahbaz et al., 2015; Din et al., 2022). RD is defined as the ratio of total highway mileage to regional land area; (4) Non-agricultural industrial development level (NONA). Different levels of industrial development play a crucial role in environmental dynamics (Wang et al., 2013; Zhu et al., 2016; Aboagye et al., 2020; Muhammad et al., 2022). Here, the impact of non-agricultural industries on environmental sanitation is controlled, with NONA captured by the share of secondary and tertiary industry value-added in regional GDP; (5) Fiscal expenditure level (FEL). Local government's environmental protection investment is constrained by fiscal capacity (Lin and Zhu, 2019; Li et al., 2023). Here, the impact of government fiscal expenditure on environmental sanitation is controlled, with FEL represented by the ratio of local fiscal expenditure to regional GDP; (6) Human capital level (HCL). Many studies indicate that higher and better educational quality can not only promote economic growth but also enhance environmental awareness (Ikazaki, 2014; Sapci and Shogren, 2018; Çakar et al., 2021). Here, the impact of human capital on environmental sanitation is controlled, with HCL calculated as the proportion of regular secondary school students in the total population; (7) Foreign trade level (FTL). Many scholars have explored the impact of open economy on environmental pollution (Wang et al., 2022), which can be divided into the "pollution halo hypothesis" and the "pollution haven hypothesis"

(Reppelin-Hill, 1999; Sadorsky, 2014). FTL is measured as the ratio of total exports (converted to RMB at current exchange rates) to regional GDP.

3.2.3 Mechanism variables

The mechanism variables are categorized into three groups:

The first category encompasses sanitation infrastructure. A well-governed city implies clean and comfortable roads, a governance concept that was centrally embodied in the "Paris Street Maintenance Management Regulations" issued by Francis I in 1,539. Research indicates that street surface pollution is a critical factor in urban environmental deterioration (Christenson et al., 1978; Sutherland and Tolosa, 2000). Up to 85% of environmental particulate matter (PM10) originates from road dust accumulation (Amato et al., 2010). This underscores the importance of developing urban road sweeping programs.

Historically, municipal authorities have used road sweeping as a fundamental means to remove garbage, dirt, and miscellaneous debris, serving both urban aesthetics and sanitation needs. Road sweeping is a core component of municipal solid waste management (Sevilla et al., 2013; López et al., 2017), primarily aimed at removing road debris and sediments, effectively suppressing pollutant dispersal into the natural environment. Consequently, road sweeping has become a critical environmental governance practice (Järlskog et al., 2020; Casotti and Alves, 2021) and is recognized as a best management practice (BMP) for pollution prevention. Currently, most cities in North America and Europe implement road dust management strategies, employing diverse cleaning methods (Amato et al., 2010; Das and Wiseman, 2024). However, this environmental governance initiative comes at a significant cost. In Italy, road sweeping operational expenses already accounted for 12.6% of total municipal solid waste management expenditures in 2014 (Ragazzi et al., 2023), reflecting the government's resource investment in sanitation infrastructure.

Accordingly, four variables of sanitation infrastructure are chosen: (1) Road sweeping area (RSA); (2) Mechanized road sweeping area (MRSA); (3) Specialized sanitation vehicles (SSV); (4) Harmless treatment plants (HTP).

The second category measures governmental environmental attention. The selection of this variable primarily derives from attention-based theory. Recent studies (Du et al., 2024; Chu et al., 2024) suggest that government environmental priorities are reflected in official documents and work reports. Following this literature, we employ two indicators: (1) Absolute frequency of environmental sustainability (AFES), which counts the occurrence of environmental sustainability-related terms in Government Work Reports; (2) Relative frequency of environmental sustainability (RFES), measured as the ratio of environmental sustainability-related terms to total word count in these reports.

The third category assesses public environmental attention. With the advancement of internet technology, web search data, which records user behavior, enables real-time capture of public attention towards specific events (Yang and Zhu, 2024). When internet users employ search engines to seek environmental information, public environmental concern becomes directly observable, making search keyword volumes an effective metric for measuring public environmental attention. Following the methodological approaches of Li X. et al. (2022) and Zhou and Ding (2023), this study employs two indicators to measure public environmental attention: (1) Environmental pollution search index (EPSI), derived from Baidu search volumes using "environmental pollution" as the keyword. Unlike international research that typically uses Google search indices (Ettredge et al., 2005; Da et al., 2011), this study employs the Baidu search index. This is primarily because Google withdrew from mainland China in 2010, resulting in low local user engagement (Du et al., 2019). In contrast, Baidu stands as the most prevalent Chinese search engine globally, dominating the Chinese market. It controls an impressive 80.5% market share and boasts over one billion users. The Baidu search index contains rich search information and serves as the most representative user behavior tracking tool in China (Luo et al., 2023; Jin et al., 2022); (2) Smog search index (SSI), calculated from Baidu search volumes using "smog" as the keyword. Accompanying the process of urbanization and industrial development, numerous Chinese cities have been plagued by severe smog, with a significant pollution event occurring in the central and eastern regions of China in December 2013 (Li et al., 2024). The smog poses a serious threat to public health, potentially triggering various health complications (Chen G. B. et al., 2018; Yin et al., 2019; Guo et al., 2020). The 2015 documentary "Under the Dome" significantly raised social awareness about the hazards of air pollution (Huang and Yang, 2020; He and Shi, 2023). The public extensively discussed air pollution through online platforms like Baidu, and this social media pressure compelled the government to implement more proactive governance measures (Li et al., 2021). For instance, sustained public attention prompted the Chinese Premier to incorporate PM2.5 detection indicators into the "Ambient Air Quality Standards" (Lu et al., 2018). Thus, public attention to smog significantly serves as a proxy for comprehensive environmental concern.

Figure 2 illustrates the conceptual framework of variables.

3.3 Data sources and descriptive statistics

Our empirical analysis draws on a balanced panel dataset covering 285 prefecture-level cities in China over the period 2001–2023. We obtain our primary data on urban environmental sanitation from the China Urban Construction Statistical Yearbook. Additional data are collected from the Provincial Statistical Yearbook and China City Statistical Yearbook. To handle occasional missing observations, we supplement our dataset with information from local National Economic and Social Development Statistical Bulletins and, when necessary, employ mean imputation methods. Table 1 reports the descriptive statistics for all variables included in our analysis.

4 Empirical results and analysis

4.1 Baseline regression analysis

Table 2 presents the regression results from our DID analysis examining the impact of NCC brand designation on urban

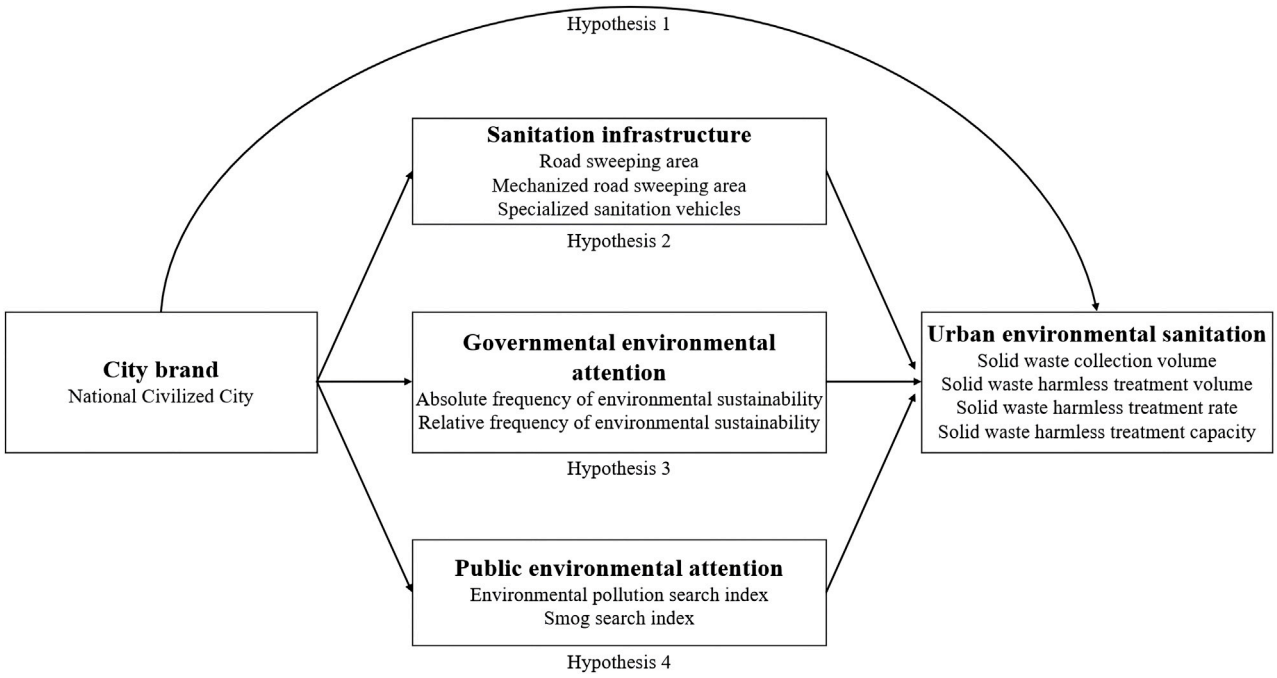

FIGURE 2
Conceptual framework diagram.

TABLE 1 Descriptive statistics.

Variable classification	Variable	Observations	Mean	Standard error	Min	Max
Explained variables	CV	6,380	49.607	88.622	0.800	1,011.160
	HTV	6,380	45.644	85.807	0.500	1,011.160
	HTR	6,380	89.496	16.765	6.603	100
	HTC	6,380	16.080	30.784	0.350	456.880
Control variables	PGDP	6,380	3.869	3.276	0.140	25.691
	UL	6,380	51.726	16.986	9.949	99.894
	RD	6,380	9.026	5.313	0.209	28.063
	NONA	6,380	85.610	9.342	42.821	99.961
	FEL	6,380	17.127	9.913	2.790	87.171
	HCL	6,380	5.775	1.467	2.669	14.925
	FTL	6,380	11.139	19.610	0.004	188.316
Mechanism variables	RSA	6,380	1.874	2.224	0.010	16.804
	MRSA	6,380	1.306	1.853	0.010	18.881
	SSV	6,380	452.829	530.539	6	9,254
	HTP	6,380	2.308	2.413	0	43
	AFES	6,380	77.647	28.150	9	166
	RFES	6,380	1.381	0.464	0.108	3.111
	EPSI	3,480	21.097	25.480	0.623	164.507
	SSI	3,480	34.345	45.339	1.156	651.055

TABLE 2 Regression results of city brand on urban environmental sanitation.

Variable	(1) CV	(2) CV	(3) HTV	(4) HTV	(5) HTR	(6) HTR	(7) HTC	(8) HTC
D × T	33.057*** (5.204)	15.202*** (3.806)	40.024*** (6.146)	20.875*** (4.226)	2.918** (1.300)	2.572* (1.378)	15.873*** (2.542)	8.054*** (1.896)
PGDP		6.786*** (1.491)		7.174*** (1.678)		−0.199 (0.332)		3.115*** (0.869)
UL		−0.886 (0.541)		−1.384** (0.640)		−0.178 (0.174)		−0.824** (0.327)
RD		0.734 (0.664)		1.140 (0.781)		0.870*** (0.236)		0.375 (0.268)
NONA		0.001 (0.229)		−0.205 (0.244)		−0.157 (0.147)		−0.072 (0.115)
FEL		−0.321 (0.214)		−0.194 (0.186)		0.003 (0.140)		−0.027 (0.086)
HCL		2.648** (1.201)		2.724** (1.303)		−0.037 (0.433)		0.487 (0.523)
FTL		−0.627** (0.305)		−0.750** (0.342)		−0.035 (0.043)		−0.288*** (0.108)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380
Adj-R^2	0.908	0.923	0.877	0.898	0.405	0.415	0.786	0.817

Note: Values in () are standard errors. ***, **, * denote significant at 1%, 5% and 10% confidence levels, respectively, as follows.

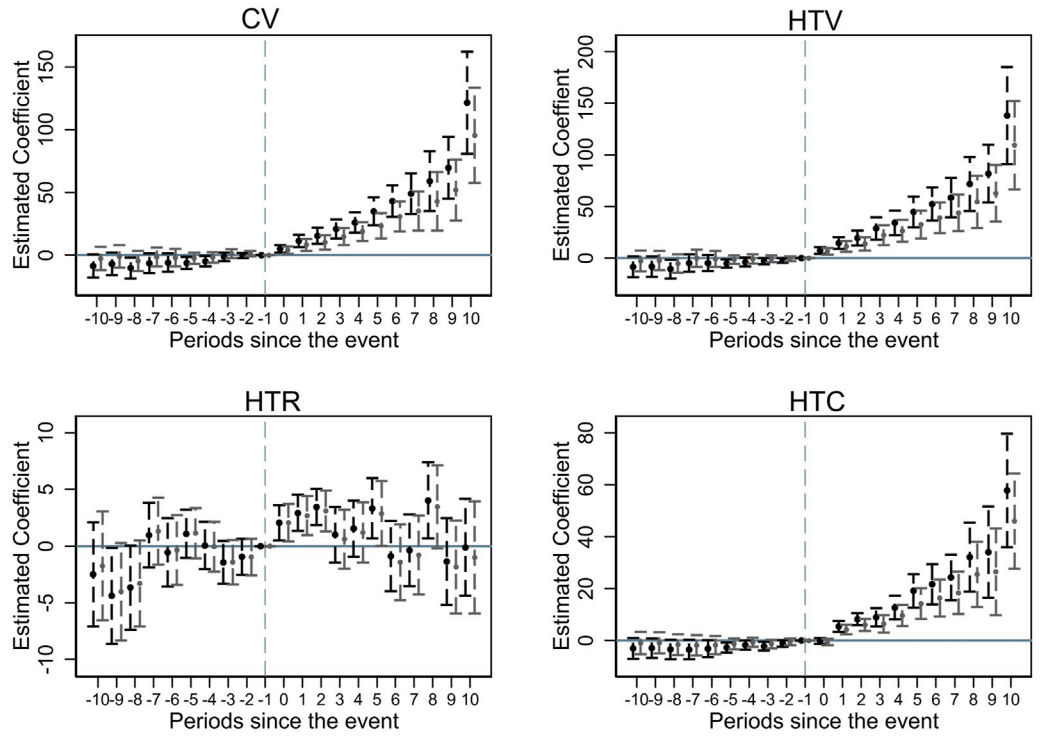

FIGURE 3
Parallel trend test.

environmental sanitation. The findings demonstrate that NCC brand designation significantly enhances all four sanitation metrics, both with and without control variables. Specifically, when control variables are added, the results in columns (2), (4), (6), and (8) show that, compared to non-NCC cities, designated cities experience increases of 152,020 tonnes in collection volume (CV), 208,750 tonnes in harmless treatment volume (HTV), 2.572 percentage points in harmless treatment rate (HTR), and 805.4 tonnes per day in harmless treatment capacity (HTC). The coefficient estimates are consistently smaller when control variables are included, suggesting the presence of confounding factors affecting urban sanitation outcomes. Among the control

variables, economic development level (PGDP) exhibits positive associations with CV, HTV, and HTC. And human capital level (HCL) positively influences both CV and HTV. Conversely, urbanization level (UL) shows negative correlations with HTV and HTC, while foreign trade level (FTL) demonstrates negative associations with CV, HTV, and HTC. These findings collectively substantiate that NCC brand designation contributes significantly to enhanced urban environmental sanitation.

4.2 Parallel trend test

A fundamental assumption underlying the difference-in-differences (DID) methodology is the parallel trends hypothesis. This assumption requires that treatment and control groups would have followed similar temporal trajectories in urban environmental sanitation indicators had the intervention not occurred. To rigorously examine this critical assumption and investigate the dynamic temporal effects of the policy, we implement the event study methodology pioneered by Jacobson et al. (1993). The dynamic specification is formalized in Equation (2):

$$Y_{it} = \beta_0 + \lambda_t \sum_{t=-10, t\neq -1}^{t=10} D_i \times Year_t + \beta_1 Z_{it} + \mu_i + \eta_t + \varepsilon_{it} \quad (2)$$

$Year_t$ represents a series of year dummy variables, while $D_i \times Year_t$ captures the interaction terms between the policy indicator and these year dummies. We normalize our analysis by designating the year immediately preceding NCC designation (t = −1) as the benchmark period, thus omitting it from the regression specification. All other variables retain their definitions as previously established in Equation (1). The coefficients of primary interest, λ_t, measure the relative differences in environmental sanitation outcomes between treatment and control groups in each year t relative to the benchmark year.

The interpretation of these coefficients serves dual analytical purposes. First, the statistical insignificance of λ_t coefficients in pre-treatment periods would validate the parallel trends assumption, confirming that treatment and control groups exhibited similar trajectories before the intervention. Second, the magnitude and significance of λ_t coefficients in post-treatment periods quantify the dynamic evolution of treatment effects following NCC designation, allowing us to track how the impact of the policy unfolds over time.

As illustrated in Figure 3, the black dashed line depicts estimates without control variables, while the gray dashed line shows estimates with controls. Prior to NCC designation, the coefficient estimates of the core explanatory variables exhibited fluctuations around zero, with their 95% confidence intervals consistently containing the zero line and showing no statistical significance. This pattern demonstrates the absence of systematic pre-existing differences between treatment and control groups, validating the parallel trends assumption crucial to our quasi-experimental design. Following NCC designation, the coefficient estimates for all core environmental indicators show positive and statistically significant deviations from zero. These results provide strong evidence that obtaining NCC brand generates substantial positive impacts on urban environmental sanitation in treatment cities. The estimated coefficients for CV, HTV, and HTC demonstrate a gradual upward trajectory over time, suggesting that the policy's effectiveness strengthens progressively.

It is worth noting that the initial absence of significant differences in environmental sanitation between treatment and control groups, both prior to and during the NCC evaluation process, can be attributed to the comprehensive nature of the NCC assessment system. Given that the evaluation criteria encompass multiple dimensions of urban development, and waste management carries relatively modest weight in the scoring system, local governments likely allocated limited resources to this particular aspect. However, the incentive structure fundamentally shifts after obtaining the NCC brand. The credible threat of brand revocation in response to major environmental incidents or safety violations creates substantial pressure on local governments. This retention pressure, which exceeds the initial pressure of participating in NCC evaluation, motivates cities to further enhance their environmental sanitation standards. The empirical evidence demonstrates that the NCC brand effectively functions as a governance mechanism in promoting urban environmental sanitation, thereby confirming our Hypothesis 1.

4.3 Decomposition test

In contexts with staggered treatment timing, treatment effects can vary across groups and periods, complicating the consistency of effect estimation. The traditional two-way fixed effects (TWFE) estimator generates coefficients that represent weighted averages of treatment effects across all treated units and time periods. However, when treatment effects are heterogeneous across groups or time, negative weights in the averaging process may cause TWFE estimates to misrepresent the true treatment effect direction, potentially producing misleading regression results. To detect potential estimation biases more effectively, we apply the Bacon decomposition method developed by Goodman-Bacon (2021), which computes group-specific coefficients and weights. The overall DID estimator breaks down into three key comparisons: (1) NCC brand recipients *versus* never-treated cities, (2) early *versus* late NCC brand recipients, (3) late *versus* early NCC brand recipients. Table 3 shows that the comparison between late and early recipients constitutes only 14.1% of the total weight. This modest weight indicates that any bias in our TWFE estimates is minimal, confirming the robustness of our empirical findings.

We further decompose the treatment effects following the methodology developed by De Chaisemartin and D'Haultfoeuille (2020). Table 4 presents the decomposition results, revealing a total weight of 974 with zero negative weights. The diagnostic results from this multi-period DID model with heterogeneous treatment effects demonstrate that our estimator does not suffer from significant bias concerns. This finding, combined with our previous robustness checks, provides strong support for the validity of our empirical strategy and the reliability of our estimated treatment effects.

4.4 Placebo test

To address potential concerns about spurious correlations and omitted variable bias stemming from unobservable city

TABLE 3 Goodman-Bacon decomposition results.

Variable	(1) DID weighted estimation results	(2) NCC brand recipients vs Never-treated cities	(3) Early NCC brand recipients vs Late NCC brand recipients	(4) Late NCC brand recipients vs Early NCC brand recipients
CV	15.20	37.42	−17.53	−52.40
HTV	20.87	45.11	−15.57	−51.96
HTR	2.572	4.067	2.273	−4.325
HTC	8.054	18.00	−9.084	−19.17
Weight		68.52%	17.38%	14.10%

TABLE 4 De Chaisemartin and D′ Haultfoeuille decomposition results.

Variable	(1) Total weight	(2) Positive weights	(3) Negative weights	(4) Proportion of positive weights	(5) Proportion of negative weights	(6) Standard deviation
CV	974	974	0	100%	0%	80.69
HTV	974	974	0	100%	0%	97.70
HTR	974	974	0	100%	0%	7.123
HTC	974	974	0	100%	0%	38.75

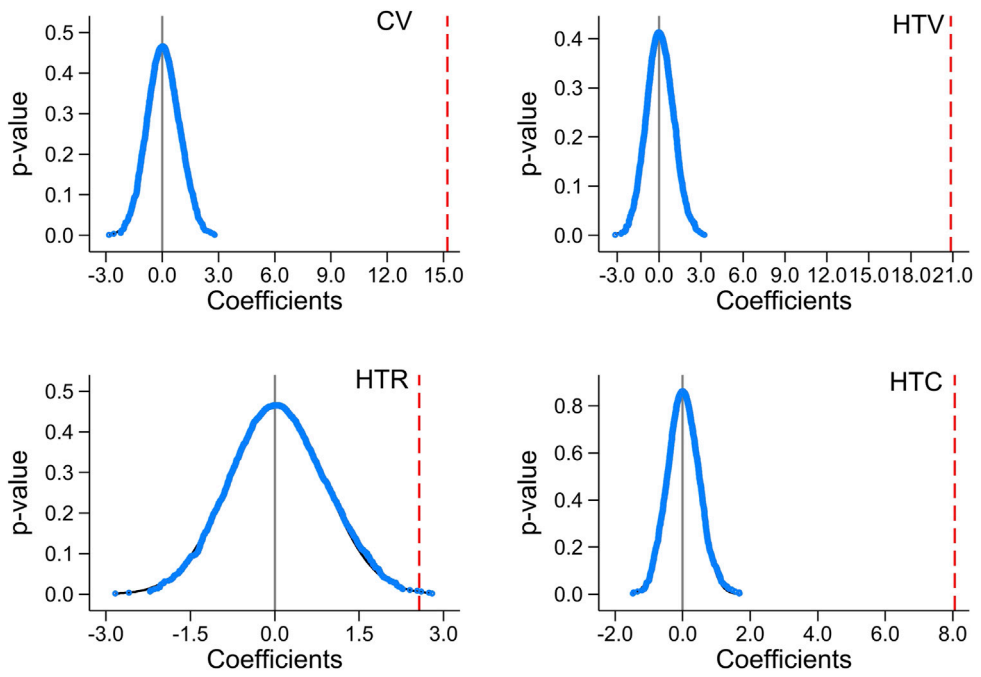

FIGURE 4
Placebo test.

characteristics that could affect our DID identification, we implement placebo tests following Li et al. (2016) methodology. These tests utilize randomized pseudo-policy shocks to validate our findings. To maintain comparability, we construct pseudo-treatment groups by randomly selecting cities proportional to the actual NCC designations in each year, thereby generating placebo estimates that exclude genuine policy effects. We repeat this randomization procedure 500 times to establish a robust distribution of placebo effects. Figure 4 illustrates the probability density distribution of these pseudo-policy impacts. In line with the null hypothesis of no effect, the estimated coefficients from placebo treatments follow a normal distribution centered at zero. The baseline regression coefficient for the interaction term (D × T), indicated by a vertical dashed line, falls in the extreme right tail of

TABLE 5 Regression results of double machine learning.

Variable	CV			HTV		
	(1)	(2)	(3)	(4)	(5)	(6)
D × T	14.006*** (1.366)	14.035*** (1.487)	14.394*** (1.166)	18.259*** (1.416)	18.635*** (1.380)	18.610*** (1.254)
Set of Control Variables for Linear Terms	Yes	Yes	Yes	Yes	Yes	Yes
Set of Control Variables for Quadratic Terms	No	Yes	Yes	No	Yes	Yes
Set of Control Variables for Cubic Terms	No	No	Yes	No	No	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	6,380	6,380	6,380	6,380	6,380	6,380
Variables	HTR			HTC		
	(7)	(8)	(9)	(10)	(11)	(12)
D × T	10.815*** (0.212)	10.829*** (0.212)	10.797*** (0.212)	8.426*** (1.212)	8.374*** (1.283)	8.477*** (1.250)
Set of Control Variables for Linear Terms	Yes	Yes	Yes	Yes	Yes	Yes
Set of Control Variables for Quadratic Terms	No	Yes	Yes	No	Yes	Yes
Set of Control Variables for Cubic Terms	No	No	Yes	No	No	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	6,380	6,380	6,380	6,380	6,380	6,380

this distribution—an outcome highly improbable under random assignment. These results counter the possibility that the observed improvements in urban sanitation are due to chance or unobserved confounding factors. Instead, they provide evidence for a causal relationship between enhanced environmental sanitation and the NCC brand.

4.5 Double machine learning causal test

Despite our previous robustness checks, selection endogeneity remains a potential concern that could affect the validity of our regression results. To address this issue more rigorously, we employ the double machine learning (DML) method. In implementing the DML procedure, we set the sample splitting ratio at 1:4 to ensure sufficient statistical power while maintaining the integrity of our cross-validation process. To minimize researcher discretion in model specification and potential overfitting, we adopt a general interactive DML framework utilizing the random forest algorithm for prediction. Our empirical strategy progressively enriches the model specification by incorporating city and year fixed effects, followed by successive additions of linear, quadratic, and cubic terms of our control variables. The results of this machine learning-based robustness check are presented in Table 5. Notably, all regression coefficients maintain their positive signs and statistical significance at the 1% level across different model specifications. These consistent findings provide strong evidence that our main results remain robust even after addressing potential endogeneity concerns through the sophisticated DML approach.

4.6 Additional robustness tests

4.6.1 PSM-DID

The selection of cities for NCC designation is contingent upon meeting specific economic and social development criteria. This non-random selection process raises concerns that external factors influencing the designation decisions may violate the parallel trends assumption fundamental to our DID framework. To mitigate potential selection bias and enhance the comparability between treatment and control groups, we employ a propensity score matching difference-in-differences (PSM-DID) approach. Specifically, we implement caliper nearest-neighbor matching to identify control cities that exhibit similar observable characteristics to the NCC-designated cities prior to treatment, followed by DID estimation on this matched sample. The PSM-DID regression results are reported in column (1) of Table 6. Notably, the coefficient estimates for all four environmental indicators remain positive and statistically significant, qualitatively consistent with our baseline findings. This consistency across estimation strategies reinforces the robustness of our main results.

4.6.2 Time interactions with initial control variables

To further strengthen our empirical strategy and address potential endogeneity concerns, we specifically focus on the

TABLE 6 Results of additional robustness test.

Variables		(1)	(2)	(3)	(4)	(5)	(6)	(7)
CV	D × T	13.876*** (3.725)	13.479*** (4.655)	16.130*** (3.559)	13.596*** (3.884)	13.550*** (3.614)	10.188*** (3.070)	6.372* (3.683)
	City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	N	4,642	6,380	6,380	6,270	6,090	6,380	3,635
	Adj-R^2	0.916	0.938	0.929	0.907	0.928	0.938	0.925
HTV	D × T	18.902*** (4.190)	18.192*** (5.169)	21.508*** (4.019)	17.270*** (4.122)	18.950*** (3.960)	15.496*** (3.420)	11.264*** (3.854)
	City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	N	4,642	6,380	6,380	6,270	6,090	6,380	3,635
	Adj-R^2	0.892	0.920	0.909	0.881	0.904	0.916	0.899
HTR	D × T	2.199* (1.315)	1.8405 (1.440)	6.353*** (1.816)	1.371 (1.457)	2.548* (1.358)	2.498* (1.392)	3.171** (1.405)
	City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	N	4,642	6,380	6,380	6,270	6,090	6,380	3,635
	Adj-R^2	0.479	0.417	0.854	0.452	0.415	0.415	0.440
HTC	D × T	7.274*** (1.743)	6.353*** (1.816)	8.650*** (1.343)	7.894*** (1.890)	7.147*** (1.855)	5.845*** (1.578)	4.211** (1.916)
	City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	N	4,642	6,380	6,380	6,270	6,090	6,380	3,635
	Adj-R^2	0.802	0.854	0.883	0.802	0.825	0.841	0.818

possibility that the NCC brand designation might systematically influence our control variables over time. This interaction could potentially introduce bias into our estimates. To mitigate this concern, we implement a methodological refinement by introducing interaction terms between time indicators and the baseline (2001) values of our control variables. This methodological refinement serves multiple analytical purposes. First, it effectively controls for heterogeneous development trajectories across cities, accounting for the possibility that different urban areas may follow distinct growth patterns independent of the NCC designation. Second, this approach circumvents potential confounding effects arising from policy shocks that might simultaneously influence both the control variables and the outcome measures. By anchoring the control variables to their pre-treatment values, we minimize the risk of post-treatment bias in our estimates. The results of this modified specification are presented in column (2) of Table 6. While we observe some minor fluctuations in the magnitude of the coefficient estimates compared to our baseline results, the fundamental findings remain remarkably stable. Specifically, both the statistical significance levels and the directional effects of our key variables maintain their consistency, lending additional credibility to our main conclusions. This robustness check provides compelling evidence that our results are not driven by potential feedback effects between NCC designation and the evolution of city characteristics over time.

4.6.3 Winsorization at 1%

To enhance the reliability of our regression estimates and minimize the potential distortionary effects of extreme observations, we employ a widely-accepted statistical technique by winsorizing all continuous variables at the 1st and 99th percentiles. The results of this robustness check are presented in column (3) of Table 6. Notably, the estimated interaction term (D × T) maintains both its magnitude and statistical significance at levels qualitatively comparable to our baseline specifications. This consistency provides additional assurance that our main findings are not artificially driven by extreme observations in the dataset. The robustness of our results to this alternative specification further strengthens the credibility of our core conclusions regarding the impact of NCC brand.

4.6.4 Province-by-year fixed effects

To further strengthen our identification strategy, we address potential confounding factors that might arise from province-level heterogeneity in policy implementation and unobservable characteristics. Specifically, we augment our baseline specification with province-by-year fixed effects, a methodological refinement that effectively controls for any time-varying provincial policies or economic conditions that could influence our outcomes of interest. The results of this enhanced specification are presented in column (4) of Table 6. After incorporating these comprehensive province-specific time trends, our findings demonstrate remarkable

consistency with the baseline results. The interaction term (D × T) maintains both its positive coefficient and statistical significance across most of our dependent variables. However, it is worth noting that the effect on the Harmless Treatment Rate (HTR) loses its statistical significance under this more demanding specification. This nuanced finding suggests that while the NCC brand generally exhibits robust positive effects on urban environmental performance, its impact on certain specific metrics may be more sensitive to provincial-level temporal dynamics.

4.6.5 One-period lagged control variables

To address potential endogeneity concerns stemming from simultaneous feedback effects between NCC brand and our control variables, we re-estimate our baseline model using one-period lagged values for all control variables that helps mitigate reverse causality concerns by ensuring that control variables are predetermined relative to the dependent variables. The results of this alternative specification are presented in column (5) of Table 6. Both the magnitude and statistical significance of the estimated coefficients remain qualitatively consistent with our baseline specifications, providing additional confidence that our main results are not driven by contemporaneous feedback effects. This robustness check further strengthens the credibility of our causal interpretation regarding the impact of NCC brand.

4.6.6 To control for the effects of other city brands

During our sample period, cities may pursue and obtain various prestigious designations beyond the NCC brand, each potentially influencing urban environmental sanitation outcomes and thus affecting our baseline estimates. To isolate the unique effect of NCC brand, we augment our baseline specification by incorporating controls for other prominent city brands, specifically the National Hygienic City, Low-Carbon City, and National Environmental Protection Model City designations. The results of this expanded specification are reported in column (6) of Table 6. Notably, after controlling for these alternative city brands, both the magnitude and statistical significance of the estimated coefficients across all four dependent variables remain qualitatively similar to our baseline findings. These results demonstrate that our main findings remain robust to the inclusion of controls for other relevant city brands.

4.6.7 Mitigating spillover effects

The NCC brand of a city could potentially generate spatial spillover effects, influencing the environmental sanitation conditions of neighboring cities. Such spillover effects, if present, might introduce bias into our baseline estimates. To address this potential source of contamination, we exclude all control cities that share geographical boundaries with cities that obtained NCC brand from our analysis. The results from this restricted sample are presented in column (7) of Table 6. The interaction terms maintain their positive and statistically significant coefficients across all dependent variables, consistent with our baseline findings. This robustness check demonstrates that the positive effects of NCC brand on urban environmental sanitation are not affected by spatial spillovers.

5 Further analysis

5.1 Mechanism analysis

According to the policy signaling theory (Erdem and Swait, 2016), obtaining the NCC designation transcends mere city branding. It serves as a sophisticated mechanism of public accountability, simultaneously elevating urban reputation while subjecting municipalities to heightened scrutiny and intensified public expectations. Drawing on attention-based theory (Simon and March, 1957), the periodic brand revalidation mechanism transforms short-term evaluation pressures into enduring urban governance motivation. To maintain this hard-earned honor and prevent potential revocation due to significant environmental issues, local governments are motivated to form institutionalized environmental governance mechanisms. This intrinsic drive compels governments to continuously focus on environmental concerns and systematically, persistently invest in sanitation infrastructure. Simultaneously, the NCC brand establishes a cross-regional urban governance performance evaluation and benchmarking learning system. Cities that initially obtain this brand become exemplary models, with their successful experiences and management approaches attracting attention and emulation from cities that later obtain the brand, thus generating a policy diffusion effect (Walker, 1969; Berry, 1994). This mechanism accelerates focused environmental attention and systematically elevates the overall standard of sanitation infrastructure development.

Drawing on policy feedback theory, public policies not only alter resource allocation but also reshape citizens' cognitive frameworks (Mettler, 2002). Upon obtaining a national-level policy brand such as the "National Civilized City" designation, a city signals more than just central government validation of its governance capabilities, crucially, it transmits an unambiguous policy orientation signal to society. This policy signal constructs an "environmentally friendly" identity label, whereby citizens, perceiving their city as officially defined as "civilized," spontaneously adjust their behaviors to align with this collective identity. Consequently, public expectations and attention toward urban environmental issues correspondingly intensify.

Based on the above analysis, we will next examine the mechanism of how the NCC brand improves urban environmental sanitation from three dimensions: sanitation infrastructure, government environmental attention, and public environmental attention.

5.1.1 Sanitation infrastructure

In terms of sanitation infrastructure, our empirical evidence indicates that NCC brand has substantially strengthened the comprehensive "front-middle-end" system of urban sanitation facilities. Specifically, at the front-end collection stage, as shown in columns (1) and (2) of Table 7, the NCC brand increases the total road sweeping area (RSA) by 0.175 and the mechanized road sweeping area (MRSA) by 0.241, both statistically significant at the 5% level, demonstrating enhanced urban cleaning capacity. The mechanization of road cleaning operations signifies a transition toward more efficient and systematic urban cleaning practices. Regarding the middle-end transportation stage, column (3) of

TABLE 7 Mechanism analysis results.

Variable	(1) RSA	(2) MRSA	(3) SSV	(4) HTP	(5) AGEC	(6) RGEC	(7) RSA	(8) MRSA
D × T	0.175** (0.080)	0.241** (0.102)	70.691*** (26.773)	0.549*** (0.135)	8.226*** (1.814)	0.094*** (0.029)	4.321*** (0.987)	11.37*** (3.562)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6,380	6,380	6,380	6,380	6,380	6,380	6,380	6,380
Adj-R^2	0.960	0.877	0.886	0.834	0.662	0.723	0.964	0.893

TABLE 8 Mechanism analysis results with initial control variables-time interactions.

Variable	(1) RSA	(2) MRSA	(3) SSV	(4) HTP	(5) AGEC	(6) RGEC	(7) RSA	(8) MRSA
D × T	0.079 (0.091)	0.107 (0.118)	66.582** (28.452)	0.435*** (0.140)	9.383*** (1.883)	0.106*** (0.031)	3.634*** (0.920)	9.686*** (3.184)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6,380	6,380	6,380	6,380	6,380	6,380	3,475	3,475
Adj-R^2	0.964	0.893	0.894	0.864	0.665	0.727	0.971	0.867

Table 7 shows that the NCC brand increases the fleet size of specialized sanitation vehicles (SSV) by 70.691, which is statistically significant at the 1% level. This expansion in transportation capacity reflects a strengthened waste collection and transportation system, enabling more efficient and timely waste management operations throughout the urban area. For the back-end processing, column (4) of Table 7 indicates that the NCC brand increases the number of harmless treatment plants (HTP) by 0.549, which is statistically significant at the 1% level. This growth in terminal waste treatment facilities demonstrates an enhanced capacity for environmentally responsible waste disposal and processing, ensuring sustainable long-term waste management solutions. These empirical findings collectively suggest that obtaining the NCC brand serves as a catalyst for developing a comprehensive and integrated sanitation infrastructure system, directly improves urban environmental sanitation, and provides strong support for Hypothesis 2.

5.1.2 Government environmental attention

Regarding governmental environmental attention, our text analysis of Government Work Reports, as shown in columns (5) and (6) of Table 7, reveals a significant increase of 8.226 and 0.094 in both the absolute and relative frequencies of environmental sustainability (AFES and RFES) following NCC brand. This shift indicates that the NCC brand can lead local governments to place greater emphasis on environmental protection, ultimately contributing to improved urban sanitation outcomes. These empirical findings provide strong support for Hypothesis 3.

5.1.3 Public environmental attention

Regarding public environmental attention, as evidenced in columns (7) and (8) of Table 7, the Baidu search index analysis shows that both environmental pollution search index (EPSI) and smog search index (SSI) increased significantly by 4.321 and 11.37 after obtaining NCC brand. This means that the NCC brand significantly amplifies public attention of and engagement with environmental issues. This increased public attention and concern create bottom-up pressure for environmental improvements, encouraging both government and enterprises to strengthen their environmental protection efforts. Moreover, heightened public environmental consciousness often leads to more environmentally responsible individual behaviors, such as proper waste disposal and participation in environmental protection activities, which collectively contribute to better urban environmental sanitation. These findings provide robust support for Hypothesis 4.

These empirical findings collectively suggest that obtaining the NCC brand improves urban environmental sanitation through three interconnected pathways: First, enhanced infrastructure provides the physical foundation for better waste management and sanitation services. Second, increased governmental attention ensures policy support, resource allocation, and effective supervision for environmental initiatives. Third, heightened public attention creates social pressure for environmental improvements while promoting environmentally responsible individual behaviors.

To further strengthen the robustness of our mechanism analysis and address potential endogeneity concerns, we employ an alternative specification by transforming the control variables into interaction terms between their initial values in 2001 and time indicators. This approach effectively "locks in" the pre-treatment characteristics of cities, allowing us to control for differential trends that might be related to cities' initial conditions. As presented in Table 8, the results are largely consistent with those in Table 7, suggesting that our findings are not artifacts of particular modeling choices or unobserved city-specific developmental trends.

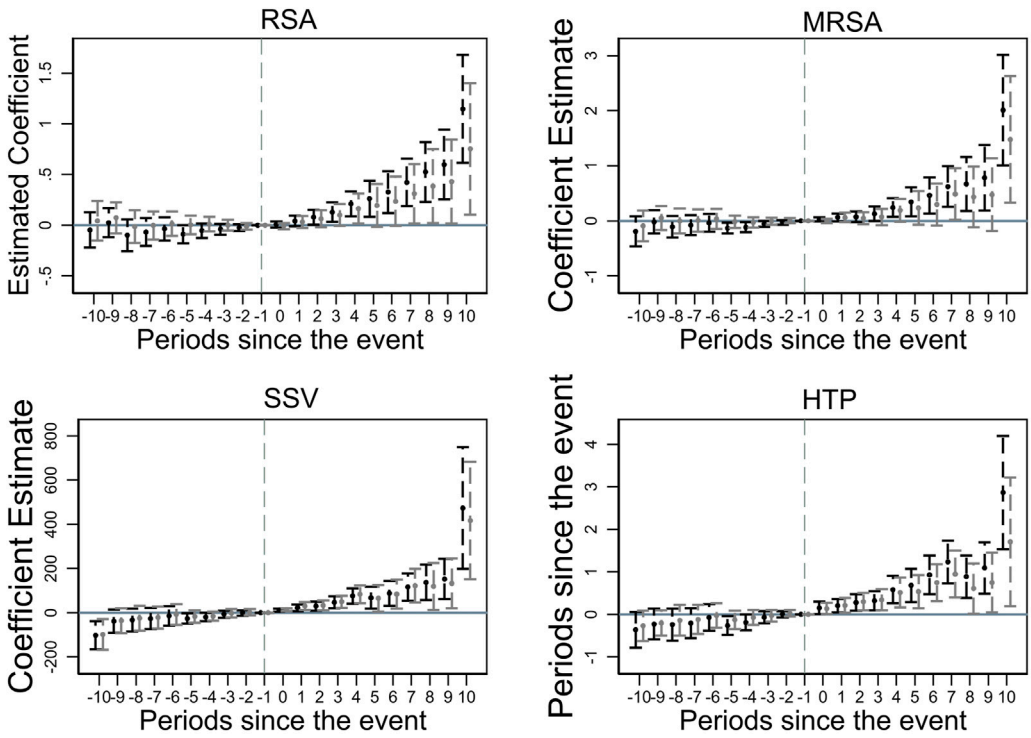

FIGURE 5
Parallel trend test of sanitation infrastructure mechanisms.

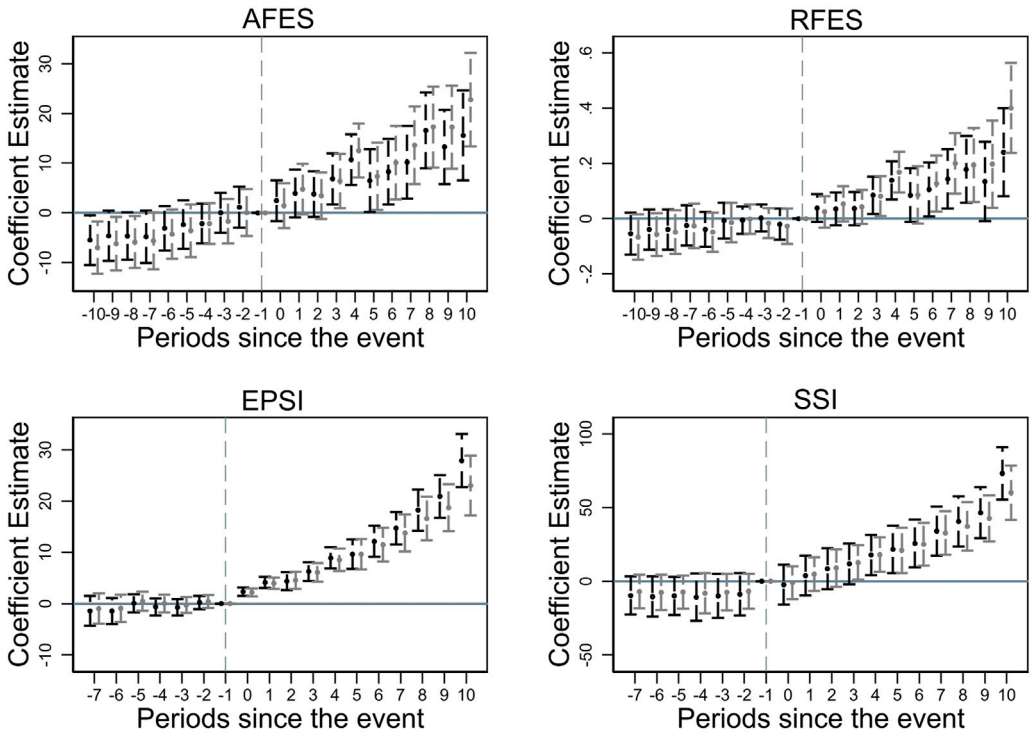

FIGURE 6
Parallel trend test of environmental attention mechanisms.

TABLE 9 Regression results of administrative hierarchy heterogeneity.

Variable	CV		HTV		HTR		HTC	
	Regular cities	Provincial capitals	Regular cities	Provincial capitals	Regular cities	Provincial capitals	Regular cities	Provincial capitals
D × T	5.259** (2.158)	11.422 (9.579)	8.449*** (2.043)	19.948* (10.982)	2.469 (1.669)	2.800 (2.080)	5.008*** (0.993)	3.122 (5.400)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5,566	814	5,566	814	5,566	814	5,566	814
Adj-R^2	0.887	0.938	0.819	0.925	0.436	0.561	0.786	0.844
Observed difference	−6.162		−11.499		−0.332		1.887	
Empirical p-value	0.000		0.000		0.099		0.000	

To rigorously investigate the temporal evolution of the NCC brand's impact on each mechanism variable, we implement an event study methodology, which allows us to trace the dynamic treatment effects both before and after the NCC designation. Figures 5 and 6 presents a comprehensive visualization of these dynamic effects through two distinct specifications. The black dashed lines depict the temporal patterns using our baseline specification with conventional control variables, while the gray dashed lines represent an alternative specification employing interaction terms between the initial (2001) values of control variables and time indicators to account for heterogeneous urban development trajectories. The event study results yield several noteworthy findings. First, prior to the NCC designation, the coefficients for all mechanism variables exhibit statistical insignificance and oscillate minimally around zero, providing strong empirical support for the parallel trends assumption. Second, following the NCC designation, we observe a clear structural break in the coefficient patterns. The estimates become progressively positive and statistically significant, demonstrating a consistent upward trajectory across all three mechanism channels. Moreover, the persistent and increasing magnitude of the coefficients over time indicates that these effects are not merely transitory but rather demonstrate cumulative dynamics, suggesting a sustainable transformation in urban environmental governance practices after obtaining the NCC brand.

5.2 Heterogeneity analysis

The influence of NCC brand on urban environmental sanitation may vary significantly across different categories of cities. To gain deeper insights into these variations, we conduct a comprehensive analysis of the heterogeneous effects of NCC brand designation on urban sanitation through two critical dimensions: administrative hierarchical status and urban agglomeration characteristics. This nuanced examination allows us to better understand how the impact of NCC brand manifests differently based on a city's administrative level and its position within larger urban networks.

5.2.1 Administrative hierarchy

We stratify our sample into two distinct groups - regular cities and provincial capitals (including municipalities) - and conduct separate regression analyses. The results, presented in Table 9, reveal striking differences in the impact of NCC brand. For regular cities, obtaining the NCC brand makes municipal solid waste collection volume (CV), harmless treatment volume (HTV), and harmless treatment capacity (HTC) increase significantly by 5.259, 8.449, and 5.008, respectively. In contrast, provincial capitals demonstrate a more limited response, only making harmless treatment capacity (HTV) significantly increase by 19.948.

The inter-group coefficient comparisons clearly indicate that the NCC brand generates more substantial improvements in environmental sanitation in regular cities. This heterogeneity can be attributed to several structural factors. Provincial capitals, by virtue of their elevated administrative status, typically possess more robust political influence, stronger economic foundations, and more sophisticated infrastructure systems. These cities have generally achieved relatively high environmental sanitation prior to the brand designation, leading to diminishing marginal returns from the NCC brand designation. Conversely, regular cities, after obtaining the NCC brand, can leverage this opportunity to significantly enhance their environmental governance, particularly making notable progress in solid waste collection and harmless treatment. This pattern suggests that the NCC brand serves as a more powerful stimulus for environmental governance advancement in cities with greater room for improvement.

5.2.2 Urban agglomeration

Our analysis categorizes the sample into two distinct groups: cities within urban agglomerations and cities outside urban agglomerations. The empirical results presented in Table 10 reveal compelling differences in the impact of the NCC brand. For cities outside urban agglomerations (Non-UA cities), the NCC brand demonstrates statistically significant positive effects across all environmental sanitation indicators, with harmless treatment capacity (HTV), collection volume (CV), harmless treatment volume (HTV), and harmless treatment capacity (HTC) increasing significantly by 14.472, 18.517, 3.756, and 7.962,

TABLE 10 Regression results of urban agglomeration.

Variable	CV		HTV		HTR		HTC	
	UA cities	Non-UA cities	UA cities	Non-UA cities	UA cities	Non-UA cities	UA cities	Non-UA cities
D × T	10.929* (6.379)	14.472*** (4.384)	16.892** (7.610)	18.517*** (4.557)	−0.492 (1.910)	3.756** (1.894)	5.320 (3.631)	7.962*** (1.786)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2046	4,334	2046	4,334	2046	4,334	2046	4,334
Adj-R^2	0.945	0.865	0.921	0.852	0.515	0.428	0.849	0.810
Observed difference	3.544		1.625		4.248		2.642	
Empirical p-value	0.001		0.146		0.000		0.000	

respectively. In contrast, cities within urban agglomerations (UA cities) only make CV and HTV significantly increase by 10.929 and 16.892, respectively.

A comparative analysis of the coefficient differences between these two groups yields a noteworthy finding: the NCC brand's impact on environmental sanitation is substantially more pronounced in cities outside urban agglomerations. This phenomenon can be explained through the lens of network effects and competitive mechanisms. Cities within urban agglomerations maintain intensive economic connections and spatial interactions, fostering heightened inter-city competition. When a city within the agglomeration attains the NCC designation, it generates demonstration effects and competitive pressure, compelling neighboring cities to increase their environmental governance investments. Moreover, urban agglomerations typically possess more sophisticated infrastructure networks and developed factor markets, enabling more efficient allocation and flow of environmental governance resources, thereby narrowing the gap in environmental sanitation governance between NCC-branded cities and non-NCC-branded cities. Additionally, within urban agglomerations, a collaborative environmental governance mechanism may emerge, potentially mitigating the independent improvement incentives of individual cities under brand effect. In contrast, cities outside urban agglomerations demonstrate pronounced infrastructural vulnerabilities in environmental governance. Their peripheral status in regional competition amplifies the marginal utility of city brand, potentially facilitating more significant urban image transformations and resource mobilization.

6 Conclusion and policy implications

The city brand represents a vital intangible asset and strategic resource for urban development. The National Civilized City (NCC) brand, recognized as China's most prestigious urban designation, serves as a comprehensive honorary title that reflects a city's overall level of civic development. Using NCC certification as a quasi-natural experiment, this study empirically investigates the impact of the NCC brand on urban environmental sanitation through a difference-in-differences (DID) approach, analyzing panel data from 285 Chinese cities from 2001 to 2023. Our empirical analysis reveals three key findings. First, acquiring the NCC brand significantly increases municipal solid waste metrics - including collection volume, harmless treatment volume, harmless treatment rate, and harmless treatment capacity - demonstrating how the NCC brand drives improvements in urban environmental sanitation. Second, our mechanism analysis shows the NCC brand enhances environmental sanitation by improving urban sanitation infrastructure, heightening government environmental attention, and increasing public environmental attention. Third, heterogeneity analysis shows that the NCC brand has more pronounced positive effects on environmental sanitation in non-provincial capital cities and cities outside urban agglomerations.

Based on the research findings, we propose the following policy recommendations:

First, strategically leverage the city brand's leadership role in establishing robust, long-term governance mechanisms. Our empirical research conclusively demonstrates that the National Civilized City designation generates significant and enduring improvements in urban environmental sanitation, with positive effects persisting well beyond the initial certification period. This sustained impact underscores the need for cities to systematically integrate civic development initiatives with environmental governance frameworks. We recommend institutionalizing and standardizing successful practices developed during the certification process to create sustainable environmental management systems. To maintain the brand's integrity and influence, cities should implement dynamic performance monitoring systems, regular compliance audits, clear accountability measures, transparent reporting mechanisms, and structured exit protocols for non-compliant cities.

Second, develop a comprehensive collaborative governance system engaging multiple stakeholders. Environmental management is inherently complex, demanding coordinated action from government entities, private sector organizations, and community members. We advocate for establishing a multi-tiered governance framework where government provides leadership through policy development, regulatory oversight, and

program coordination; businesses implement sustainable practices and increase environmental investments; civic organizations facilitate community engagement and knowledge sharing; and residents actively participate in environmental initiatives while adopting sustainable lifestyle practices. This integrated approach ensures that each stakeholder group contributes its unique resources and capabilities toward achieving shared environmental goals.

Third, advance city brand development through locally tailored strategies, emphasizing differentiated implementation based on urban context. For developing cities, the Civilized City program should serve as a primary catalyst for enhancing environmental governance standards and practices. These cities can use the program's framework to establish foundational environmental management systems and build community support for sustainable practices. Larger metropolitan areas should pursue more sophisticated governance models, such as regional environmental coordination mechanisms and advanced sustainability initiatives. These cities can pioneer innovative approaches to urban environmental management, including cross-jurisdictional collaboration, advanced monitoring systems, and cutting-edge sustainable technologies. This tiered approach ensures that environmental governance strategies align with local capabilities while promoting continuous improvement across all urban areas.

While this study has controlled for certain city brand policy effects, the richness and complexity of urban branding systems suggest significant potential for further research. Future studies should broaden the scope of city brand analysis beyond NCC to examine other significant urban recognition programs. This expanded perspective would allow researchers to investigate the potential synergies between different types of city brands and their collective impact on urban development. Specifically, studies should explore the cumulative effects of multiple designations, determining whether different brands complement or substitute for one another.

Furthermore, our current analysis focuses primarily on municipal solid waste management. Future studies would benefit from incorporating additional environmental metrics, such as urban green space coverage and noise pollution levels. We also recommend including subjective measures, particularly resident satisfaction surveys, to evaluate environmental governance effectiveness through both quantitative and qualitative lenses. This comprehensive approach would provide a more nuanced understanding of how city brands influence urban environmental quality and public perception.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://figshare.com/articles/dataset/NCC_/28397048?file=52294148.

Author contributions

JL: Conceptualization, Data curation, Methodology, Software, Writing – original draft, Writing – review and editing. LX: Resources, Supervision, Validation, Visualization, Writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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