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Can Smart City Construction Promote Urban Green and High-Quality Development?—Validation Analysis from 156 Cities in China

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Abstract: The in-depth participation and application of new-generation information and communication technologies, such as big data, Internet of Things, artificial intelligence, etc., in the field of smart cities have promoted their abilities in urban fine governance, public services, ecological livability, scientific and technological innovation, etc. Smart cities are gradually becoming recognized as the best solution to "urban problems". Smart city construction drives urban innovative development, accumulates kinetic energy for economic growth, strengthens social support functions, enhances the effectiveness of the ecological environment, and promotes the convergence and integration of urban green development and high-quality development. This paper constructs a difference-in-differences model based on propensity score matching. Additionally, fiscal science and technology investment is introduced as mediating variables to further explain the mechanism through which smart city pilot policy impacts urban green and high-quality development. This research uses panel data from 156 prefecture-level cities in China from 2006 to 2019 to empirically test that the construction of smart cities has a significant positive effect on urban green and high-quality development. The mediation effect model shows that an increase in the level of local government's fiscal science and technology investment enhances the positive effect of smart city construction on urban green and high-quality development. This research concludes with policy recommendations: the government should seize the development opportunity presented by smart city pilot policy, providing necessary policy support and financial incentive for the construction of smart cities. This will optimize the local economic structure, transform the driving forces of urban development, and assist cities in achieving green and high-quality development.

Keywords: smart city; green and high-quality development; financial and scientific investment; difference-in-differences model

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1. Introduction

At present, China's economy has shifted from high-speed growth to high-quality development, and it is in a critical period of transforming its development mode, optimizing its economic structure, and transforming its growth momentum. In the context of resource constraints, the integration of environmental considerations into economic development assessment frameworks has become a necessity for growth. Accelerating the development process of the digital economy and promoting the in-depth integration of the digital economy and the entity economy provide the direction and basic guidelines for China's high-quality green development. Compared with the traditional economy, the green attribute of the digital economy not only reduces energy consumption and environmental pollution but also creates a new endogenous engine for economic growth [1,2]. As an important carrier of the digital economy, the smart city fully embodies the perception, interconnection, and intelligence of urban development [3], which is the further continuation and development of the digital city in terms of content. Meanwhile, smart city construction highlights the information element and humanistic factors in all fields of urban management and promotes the gradual realization of urban green and high-quality development, which is an important path to optimizing the economic structure [4]. Smart city construction is regarded as an intelligent infrastructure system that integrates physical and information infrastructures, with the promotion of innovative applications of information technology.

China's economic and social development has been rising steadily, and its residents' standard of living has improved markedly. However, China's future development is also facing a number of substantive challenges, such as inefficient allocation and utilization of resources; uncoordinated regional development; and the frequent occurrence of urban problems of traffic congestion, housing tension, inadequate water supply, energy shortage, and environmental pollution that occur in the process of urban development. Sustainable growth is being hampered by the increasing issues of energy and environmental pollution, as well as by the lack of focus on ecological preservation and whole-process environmental management. In 2012, in order to plan and manage cities intelligently, allocate resources in a scientific and rational manner, and enhance urban livability, the Ministry of Housing and Construction (MOHURD) released a list pertaining to a smart city pilot for the first time and began to incorporate the concepts of high-quality green development, such as intensification, low carbon use, ecology, and intelligence, into the specific process of urban development. Under the guidance of the policy, a number of provinces and cities have issued similar policies for smart city development, which can bridge national requests and guide local urban development. Gradually, an effective smart city development pattern of sectoral linkages, upward and downward synergies, and hierarchical articulation is taking shape so that smart city development can better serve the human-centered urban development process.

It is argued in the related research that smart city construction has the ability to efficiently and rationally allocate urban information resources, which can effectively enhance urban resilience and optimize social management and public services, and that it is the optimal choice for promoting the intensification of the development mode [5]. More and more cities regard smart city construction as a new engine for urban development. They have combined the concept of green development with the promotion of high-quality urban development, enhancing urban resilience and competitiveness. As a developing country, resource demand is on the rise, and economic development is facing huge ecological and environmental pressures. Environmental governance has not yet shifted from end-to-end control to front-end prevention and whole-process governance, and there is an urgent need to construct a perfect green development system. Therefore, the green and high-quality development model oriented toward economic development, constrained by environmental protection, and aiming at coordinated development has been widely recognized by the community [6].

The high-level economic scale and high-level science and technology are vital premises for smart cities to expand green space [7]. Smart city construction has the positive effects of enhancing urban innovation standards, optimizing urban industrial structure [8], and reducing urban environmental pressure [9], which comprise an important path to promote the convergence and integration of urban green development and high-quality development. Smart city pilot policy contributes more significantly to energy conservation innovation at the source and technology-based green innovation than end-of-pipe governance innovation and administration-based green innovation [10]. Of course, there are some limitations to the research on China alone, but the research on smart city construction is still representative. The existing environment of policy, technology, and practice indicate that China is the most suitable country for smart city development [11], which has gradually become an important driving force to promote the transformation of urban economic kinetic energy, ecological efficiency, and social function improvement and is of great significance to the realization of green and high-quality development.

2. Literature Review

2.1. Smart City Construction

As noted above, smart city construction can be further understood as a project that utilizes new technologies and concepts to continuously reshape urban development. It is the integration of information technology into the process of urban planning and construction management, making urban functions more coordinated and efficient in order to comprehensively improve the level of urban public services and the effectiveness of social governance. Initially, the concept of the smart city focused only on the integration and development of information technology and urban modern infrastructure construction [12,13]. With the continuous exploration and practice of smart city construction, currently, it covers various forms of technological innovation in urban planning, operation, and management. Most scholars believe that smart city construction reflects multiple aspects of social well-being, government governance, economic prosperity, urban sustainability and livability, etc. For example, Qingdao has optimized its comprehensive monitoring and early warning system for urban security risks through the construction of a comprehensive monitoring and early warning platform for urban security risks. The smart city construction in Fuzhou has enhanced public services such as transportation and travel, healthcare, and housing security, driven by data and applications. K.A. Paskalevak and J.M. Eger believed that smart cities promote urban economic prosperity and comprehensive competitiveness through the application of information technology and achieve urban comprehensive development [14,15]; T. Nam, T.A. Pardo, G.C. Lazaroiu, and M. Roscia elaborated that the key to smart city construction is "humanization", i.e., the city intelligently integrates and allocates resources to achieve the integration of information infrastructure and traditional infrastructure, which improves residents' lives and sustainable economic growth [16,17]; T. Yigitcanlar further stated that the smart city is the ideal form of urban green and high-quality development, which represents the balanced development of politics, economics, society, and the environment [18]. Despite the lack of clarity in academia about the specifics of smart city construction, its positive role in terms of urban technological progress, economic growth, environmental friendliness, and efficient governance has been widely recognized by scholars. In the economic aspect, smart city construction promotes urban technological progress and the emergence of new industries as well as drives urban economic growth through the innovation effect [19,20]. In terms of social development, the smart city helps to improve urban information systems. In the smart city system, all kinds of resources are rationally allocated to different fields, creating a fair and just social atmosphere [21,22]. From the perspective of the environment, the idea of sustainable development embedded in smart city construction has introduced green technology and intensive development thinking into urban development, and urban ecological efficiency has been fully realized [23,24]. In terms of urban governance, smart city construction provides local governments with the possibility of dynamic detection and fine governance. As a result, innovation in the form of urban management and a new governance model with public participation have become possible, which in turn creates more public value and significantly improves the level of urban operation and management and public services [25,26]. The existing literature considers that there are three main driving factors for smart city construction: technology, people, and systems [27,28]. In the dimension of technological effects, existing theories and practices have shown that technological innovation is the prerequisite for smart city construction, which continuously improves the level of urban innovation and promotes its long-term development on a higher level of its economic structure [29]. From the perspective of human capital, high-level composite talents stimulate the vitality of urban innovation and entrepreneurship, drive the development of new industries in the city, and enhance the kinetic energy of urban economic development [30,31]. In the dimension of policy systems, the policy contributes to stimulating the motivation of enterprises and the public to participate in the smart city project, and the government takes the initiative to actively play the role of the macro-controller to gather the necessary resources such as manpower, capital, and land for the construction of the smart city so as to build up and improve the urban innovation system and to promote the transformation of the urban development mode to an intensive one [32,33]. In China, smart city construction is mainly driven by institutions, technological innovation, intercity competition, and cooperation [34–36], and cities with significant resources for development will have an ideal power system in smart city construction, allowing the outcomes to be better applied to all aspects of society.

2.2. Urban Green and High-Quality Development

Scholars believe that high-quality economic growth based on the concept of green development is the key to urban economic development [37]. With the deep integration of various parts of society and the continuous penetration of the digital economy and digital industry, the regional economic growth model is changing, and the digital economy is regarded as a major opportunity to realize green and high-quality development by an increasing number of regions [38]. Factors affecting urban green and high-quality development have been studied from various perspectives, including market distortion, fiscal decentralization, environmental regulation, and economic globalization. Excessive government control over factor markets is known to significantly impede the development of an export trade boom and foreign direct investment (FDI) levels, thereby impeding high-quality urban development and contributing to the decline in green total factor productivity from the perspective of resource mismatch and factor distortion [39–41]. From the perspective of environmental regulation, one viewpoint is that environmental regulation generates economic benefits by promoting technological innovation and compensating enterprises for the costs incurred in reducing environmental pollution so that enterprises can improve their market competitiveness and realize economic gains at a higher level; another viewpoint is that environmental regulation has a crowding-out effect on pollution-intensive enterprises, which will choose other regions with weak environmental regulation, thus inhibiting economic growth in the region [42,43]. There is also a view that the impact of environmental regulation on urban green high-quality development shows a phased change; in the short term, environmental regulation will hinder economic growth, but in the long term, reasonable environmental regulation will provide urban ecological and economic benefits to achieve a win-win situation to promote urban green high-quality development [44]. Adhering to green high-quality development is a key path to realizing the comprehensive and coordinated development of the economy, environment, and society. Existing studies mostly explore the influencing factors of urban green high-quality development, but there is still a lot of research space in constructing and measuring an evaluation system for urban green high-quality development.

2.3. Smart City Construction and Urban Green High-Quality Development

The influence path of smart city construction on urban green high-quality development can be specifically summarized as the technical effect, structural effect, and configuration effect. First, by promoting technological innovation, smart city construction promotes urban green high-quality development, which is the starting point and foundation. It is suggested that smart city construction cannot be separated from knowledge collision and innovation drive [45]. A. Caragliu [46] believed that large-scale smart city construction projects attract the participation of high-tech enterprises, promote an increase in urban innovation output, produce technology spillover effects, and increase the level of urban technological innovation. M. Angelidou [47] analyzed the impact of smart city construction on urban green and high-quality development through the empirical analysis of 15 countries' smart cities. Through the empirical analysis of the characteristics of smart city development in 15 countries, it was found that the smart city construction in most countries attaches importance to the application of information and communication technology in improving the function of the urban system and optimizing the innovation network. Han Pioneer et al. [48] believed that the large-scale application of information technology in the construction of smart cities has caused information resources to generate innovation overflow among different subjects, thus promoting the technological progress of enterprises and the enhancement of the level of urban informatization. Secondly, smart city construction promotes urban green and high-quality development by promoting industrial structure upgrading. Smart city construction accelerates the continuous penetration and wide application of information technology, gives rise to new industries, renews market vitality, and gathers more innovative talents and high-tech enterprises for the city, which leads to the growth of high-value-added industries and the optimization and upgrading of the urban industrial structure [49–51]. In addition, for a long time, the green development in most cities has been constrained by the heavy industrial structure and coal-oriented energy consumption structure, and the continuous penetration of the concept of the smart city has prompted the introduction of new green and low-carbon technologies into traditional industries, which provides the impetus for the innovation and development of the traditional industries and is conducive to the establishment and improvement of the modern industrial system, and the urban economy has realized intensive development. Thirdly, smart city construction promotes urban green and high-quality development by optimizing the allocation of urban resources. Under the leadership of the new development concept, the governance objectives and methods of local governments accelerate the transformation to drive innovation, optimize the structure of financial expenditure to achieve a reasonable allocation of resources, and then promote the synergistic development of urban economic and ecological benefits [52]. Smart city construction has strong externalities. Increasing financial and scientific investment (FSI), implementing encouraging science and innovation policies, providing necessary financial support for technological innovation of enterprises, and guiding enterprises to actively participate in the smart city construction can allow social capital to flow more into innovative activities and realize the sustainable development of the urban economy [53,54]. At the same time, smart city construction promotes the development of urban informatization and intelligence and the rapid emergence of high-tech industries, which in turn attracts more innovative talents for the city, promotes the quantity and quality of urban human capital, and forms the knowledge spillover effect to provide a solid theoretical foundation for urban green and high-quality development [55,56].

3. Analysis of Theoretical Mechanisms and Research Hypotheses

Smart city construction, as one of the important applications of the digital economy, has a positive role in consolidating the needs of urban digital transformation and promoting the green and high-quality development of cities. Smart city construction contains five types of urban innovation, namely, product innovation, technological innovation, market innovation, resource allocation innovation, and organizational innovation, which is the engine of urban economic growth and development [57]. Innovation is the foundation of smart city construction, and the technological progress, configuration efficiency, and structural upgrading brought about by smart city construction in turn comprise the process and extension of the innovation drive, which will inevitably place city development on the road to green and high-quality development.

Product innovation drives urban technological progress and structural upgrading. As an important engine of enterprise development, the process of product innovation implies technological innovation and progress [58]. In order to seize more market share, the competition among enterprises is increasing; coupled with the increasing resource constraints in the production process, more and more enterprises actively capture the market demand, accelerate the pace of product innovation, and upgrade and iterate production equipment, production methods, and production technology. As a result, the sector has steadily developed a cycle of healthy rivalry and has modernized and optimized its internal structure. Technological innovation drives urban technological progress and structural upgrading. Smart city construction, accompanied by the breakthrough and application of emerging technologies, is conducive to the urban setting gathering professional talents, expanding capital investment, landing high-tech enterprises, and stimulating the deep-seated power of urban development, and it then enhances the level of urban technological progress [59]. At the same time, the supporting technologies in smart city construction, such as big data, the Internet of Things, cloud computing, etc., have brought new possibilities for the transformation of the urban economy and facilitated the acceleration of the process of fusion and development of traditional industries and emerging technologies, with full-speed enhancement of the efficiency and quality of the traditional industries and the rationalization of the urban industrial structure.

Innovation in the market drives urban allocation efficiency and structural upgrading. Smart city construction opens up a broad development market for emerging industries; attracts the inflow of urban labor, land, capital, and other production factors; and indirectly improves the allocation efficiency and rational allocation of urban resources [60]. In addition, the development of emerging industries will promote the development of productive service industries with high industrial added value and high industrial relevance. In turn, it will enhance the resilience of the urban industrial chain and supply chain and play a major role in optimizing the economic cycle of the productive service industry, leading the industry to climb to the top of the value chain. In turn, the key nodes of industrial technological progress, industrial structure transformation, and upgrading will be opened.

Resource allocation innovation drives urban configuration to improve efficiency. Information and communication technology is one of the core elements of smart city construction, and it plays a supporting role in the establishment and sharing of digital pedestals at the city level. With the integration and development of emerging technologies and industries, digital connectivity of management, control and operation is formed between all elements within the city to realize intelligent urban governance. Thus, it helps the main body of urban decision making to allocate resources scientifically, rationally, and efficiently.

Organizational innovation drives the efficiency and structural upgrading of urban configurations. At the micro level, smart city construction has brought emerging technologies and efficient management modes to enterprises, in which the ability of enterprise management organizations to integrate market information and internal resources has been greatly improved, while resources such as capital, labor, and information tend to be directed to low-energy-consumption and high-yield-production sectors, so that internal resource allocation has been improved in terms of quality and efficiency. At the macro level, the government can better perform its urban management functions with the help of the urban digital perception system, including supporting and guiding the development of high-tech enterprises and emerging industries and introducing targeted policies to gradually transform the urban industrial structure.

The impact mechanism of smart city construction on urban green and high-quality development is shown in Figure 1.

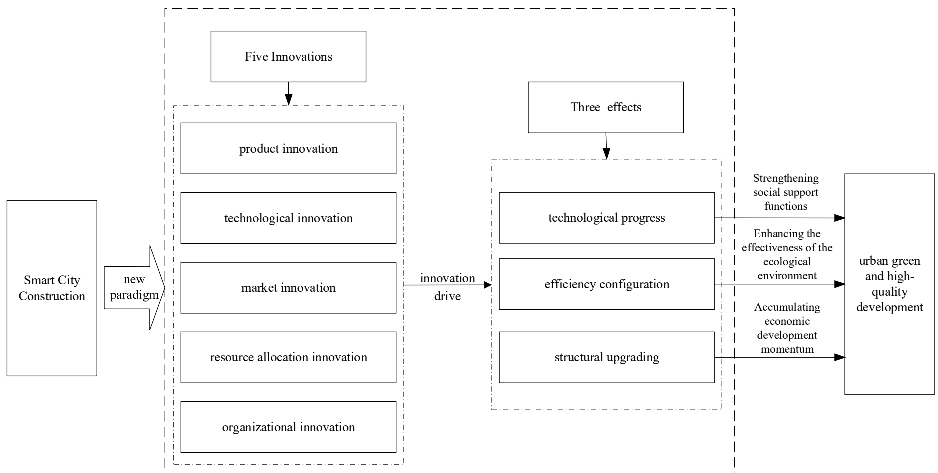

Figure 1. The mechanism of smart city construction affecting green high-quality development.

At the same time, smart city construction is a complex systematic project of urban development. In the process of smart city construction, the research and development of new technologies, cultivation of new markets, and development of new industries all need a large amount of financial support; these projects are generally characterized by a long capital recovery cycle, high investment risk, strong positive externalities, etc., and it is difficult to rely only on social capital for the supply of the market [61]. Therefore, it is necessary for the government to take the initiative to intervene in the innovative activities of smart city construction through policy guidance and financial, scientific, and technological inputs in an effective way while guiding social capital to participate in smart city construction projects to empower urban development. Most scholars believe that increased financial support will have a positive effect on the improvement of the level of smart city construction. Local governments can reduce or waive taxes for enterprises involved in smart city construction projects and provide talent subsidies for personnel engaged in technology research and development related to smart city construction, i.e., the government can help smart city construction by gathering talent and high-tech enterprises.

In terms of the direct impact of FSI on urban green and high-quality development, at the macro level, FSI has an indirect impact on economic growth by affecting the level of total factor productivity, and it encourages the regional economy to develop in a high-quality manner. At the micro level, increased government investment in science and technology can play a positive moderating role in the promotion of entrepreneurship for economic growth, which will increase the motivation of enterprises to innovate and the efficiency of innovation, thus boosting the economy [62]. Financial support plays an important role in promoting enterprise innovation, industrial upgrading, and the development of the digital economy, which has a moderating effect on the effect of smart city construction. In fact, whether a local government chooses to invest limited funds in industries with a high return rate but a low innovation level and high environmental pollution or in industries with a long payback period, high innovation level, and low environmental pollution depends on the local government's rational allocation of financial funds based on the status quo of local economic and social development. When the local government's financial investment in urban science and technology innovation is low, the social capital elements will flow to the enterprises that emphasize production but are light on innovation, and the technological progress and innovation ability of the traditional industries will be stagnant, hindering the gathering of talent and high-tech enterprises, and the construction of the smart city will lack the necessary support of knowledge, technology, information, and talent and will not effectively be able to play a role in strengthening social support, improving ecological efficiency, and stimulating the vitality of the economy. When the financial investment goes high, enterprises relying on resource consumption and labor intensity to achieve economic benefits take the initiative to transform into knowledge- and technology-intensive enterprises, forming new business forms and new industries, optimizing and upgrading the urban industrial structure, rationalizing the economic structure and energy consumption structure, sustaining the high-speed development of the construction of the smart city, and making it easier to show the three major effects of technological advancement, efficiency enhancement in configuration, and structural upgrading. The three effects of technological progress, configuration efficiency improvement, and structural upgrading can be more easily seen, and the urban economic system and development mode with innovation as the engine can be formed faster. Therefore, local governments should rationally plan the allocation of financial resources and increase the proportion of FSI in financial expenditures, which is conducive to the development of the local digital economy and innovation economy, changing the situation of the future development of cities driven by labor, resources, and energy and then better furthering the role of smart city construction in the promotion of urban sustainable, high-quality development. Accordingly, this paper puts forward the following hypotheses:

Hypothesis H1. *Smart city construction plays a direct role in promoting urban green and high-quality development.*

Hypothesis H2. *Local government FSI positively regulates the promotion effect of smart city construction on urban green and high-quality development, and the higher the level of government FSI, the more significant the role of smart city construction in promoting urban green and high-quality development.*

4. Variables and Model Construction

4.1. Description of Variables

(1) Explained variable: the level of urban green high-quality development (h).

Urban green and high-quality development encompasses the aspects of urban development of being innovation-driven and of having green ecology, openness, and sharing. In view of the increasing prominence and complexity of current urban problems, this paper divides the systematic goal of urban green and high-quality development into three first-level indicators: economic growth momentum, social support function, and ecological and environmental effectiveness. Furthermore, the economic growth momentum is divided into four secondary indicators: the level of economic development, the development of industrial structure, the level of residents' income, and the local financial situation. The social support function is divided into the development of the productive service industry, the medical and health care level, the level of informationization, and the postal service level. The ecological efficiency is categorized into industrial wastewater discharge and carbon emission level.

Among them, the level of economic development is represented by GDP per capita; the development of the industrial structure reflects the trend of the economic structure from the dominance of labor-intensive industries to the dominance of knowledge- and technology-intensive industries, which is expressed as the proportion of the added value of the tertiary industry in in the GDP; the level of residents' income is expressed by the average salary of urban workers; and the local financial status is expressed by the income of local finances within the general budget; considering the important role of the productive service industry in the benign interaction between the innovation economy and the service economy, the development of the productive service industry is characterized by the proportion of employees in the productive service industry [63], which is defined as six major industries, namely, "transportation, storage and postal services", "rental and business services", "wholesale and retail trade", "finance", "information transmission, computer services and software", and "scientific research, technical services and geological survey" [64–66]; health care level is characterized by the number of beds in urban hospitals and sanitariums; the informationization level is expressed by the number of international Internet users; the postal service level is characterized by the total amount of postal services; urban industrial wastewater emission reflects the problem of wastewater pollution and is expressed by industrial wastewater emission per unit in the GDP; and the urban carbon emission level reflects the status quo of urban air pollution and is characterized by carbon dioxide emission per unit in the GDP. This paper utilizes the entropy value method to assign appropriate weights to the indicators in the urban green high-quality development evaluation index system and then calculates the urban green high-quality development level of each city according to the weights.

(2) Adjustment variables.

The diversified fiscal S&T investment system of local governments is widely recognized as an important support for regional S&T progress, urban green innovation, and digital economy development. In this paper, FSI is selected as a moderating variable. The proportion of science expenditure in the general budgetary expenditure from local finance to regional GDP is taken as the value of fiscal science and technology input [67,68].

(3) Control variables.

This paper selects five factors as control variables: urbanization level, financial development level, opening-up level, residents' consumption demand, and industrial structure development.

The urbanization level (X) is measured by the ratio of urban resident population to total resident population. Financial development level (Y) is characterized by the ratio of the balance of RMB loans of financial institutions to the regional GDP at the end of the year. The opening-up level (G) is characterized by the amount of foreign investment actually used in the year as a share of the regional GDP, where the amount of foreign investment actually used is treated using the annual average exchange rate of the RMB in the year. Residents' consumption demand (Z) refers to the total retail sales of consumer goods as a share of the regional GDP. Industrial structure development (U) is measured by the ratio of the value added by the tertiary industry to the value added by the secondary industry [69].

4.2. Model Establishment

In quantitatively assessing the role of smart city pilot policy in promoting green and high-quality urban development, a differential method is generally used, i.e., the differences in the economic characteristics of the pilot areas before and after the implementation of the smart city pilot policy are quantified to obtain the difference estimator. Considering that the synthetic control method is unable to calculate the weight combination of the synthetic control area for the pilot smart city with special economic and social development levels [70–72] and that it is impossible to find the virtual control group of an extreme value, a difference-in-differences (DID) model is used to assess the effect of the smart city pilot policy. Based on the quasi-natural experiment of the smart city pilot, to verify its positive effect on urban green and high-quality development, a benchmark regression model is constructed as follows:

$$h_{it} = \alpha_0 + \alpha_1 Treat_{it} \times Post_{it} + \sum_{i=1}^{n} \gamma_i S_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

where i, t, and h denote the city, year, and level of urban green and high-quality development, respectively, and α_0 denotes the constant term. According to the basic requirements of constructing a DID model, $Treat_{it}$ and $Post_{it}$ are two newly set dummy variables. Treat denotes the grouping dummy variable. It adopts the first batch of pilot smart cities released by the MOHURD in 2012 as the experimental group in this paper, so the Treat value of the pilot smart cities is taken as 1, and that of the non-pilot smart cities is taken as 0. Post denotes a dummy variable for the time of policy implementation, so the value of Post is taken as 0 for the years before 2012 and 1 for the year 2012 and those after. $Treat_{it} \times Post_{it}$ is the interaction term of the grouping dummy variable and the policy implementation time dummy variable, which indicates the level of smart city construction, and α_1 indicates the net effect of the policy implementation. S_{it} denotes the control variables, including urbanization level, financial development level, opening-up level, urban consumption demand level, and industrial structure development level. γ_i denotes the effect of each control variable on urban green and high-quality development. μ_i denotes the individual fixed effect, which is used to control the individual characteristic variables that do not change over time, such as the urban geographic characteristics, and δ_t denotes the time fixed effect, which is used to control the temporal characteristic variables that do not change with the turnover of the individual, such as the domestic and foreign macro-environments. ε_{it} denotes the random disturbance term.

The smart city pilot may not be a randomized experiment and it may result in self-selection bias in the selection of experimental groups if the policy effects of smart city pilots are assessed solely using the double-difference approach. Therefore, this paper refers to the research methods from Daqian Shi [73], Caragliu A [46], Xiongyuan Wang and Lufan Bu [74], Ning Ding [75], Linlin Sun [76], Ye Guo and Fang Fang [77], and Jing Lu [78] to combine the propensity score matching (PSM) method with the DID method. The PSM method is utilized to match each pilot smart city to a specific control group sample, thus approximating the smart city pilot policy to a randomized quasi-natural experiment and eliminating the systematic differences between the experimental group and the control group in terms of the trend of changes in the level of green and high-quality development of the city. PSM is a statistical method used to process data from observational studies, and it solves the problem of high data bias and confounding variables by calculating a composite propensity score for each covariate of each observation through statistical modeling and then matching according to the proximity of the propensity scores. It is the reduction of the effects of these biases and confounding variables that allows for a more rational comparison of the experimental and control groups. The propensity score matching method with the double-difference method (PSM-DID) model constructed in this paper is as follows:

$$h_{it}^{psm} = \alpha_0 + \alpha_1 Treat_{it} \times Post_{it} + \sum_{i=1}^{n} \gamma_i S_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (2)$$

When considering the impact of the implementation of smart city pilots on urban green and high-quality development, there is the direct effect of the implementation of smart city pilot policy, and on the other hand, there is the indirect effect of the moderating variables in the relationship between smart city pilots and urban green and high-quality development. Therefore, this paper introduces FSI as a moderating variable to further explain the impact mechanism of smart city pilot policy on urban green high-quality development. Referring to the research method of Fang Jie et al. [79], the moderating effect model is constructed as follows:

$$\begin{aligned} h_{it} = {} & \beta_0 + \beta_1 Treat_{it} \times Post_{it} \times W_{it} + \beta_2 Treat_{it} \times Post_{it} + \beta_3 W_{it} \\ & + \sum_{i=1}^{n} \gamma_i S_{it} + \mu_i + \delta_t + \varepsilon_{it} \end{aligned} \quad (3)$$

where W represents the level of FSI. If the coefficient β_1 of the interaction term $Treat_{it} \times Post_{it} \times W_{it}$ is significant, it indicates that the moderating effect is significant, that is to say, FSI does play a moderating role in the relationship between the smart city pilot policy on the urban green and high-quality development. When the interaction term coefficient β_1 is consistent with the positive and negative signs of the main effect coefficient β_2, it is considered that there is a positive moderating effect and vice versa, that is, it is considered that there is a negative moderating effect. Further, the amount of moderating effect can be calculated by $\Delta R^2 = R_1^2 - R_0^2$, where R_1^2 represents the coefficient of determination in Equation (3) and R_0^2 represents the coefficient of determination after removing the interaction term $\beta_1 Treat_{it} \times Post_{it} \times W_{it}$ in Equation (3).

4.3. Data Sources and Descriptive Statistics

In 2012, the MOHURD publicized the first list of pilot smart cities, which included 90 cities. Assessment of the policy effects of smart city pilots in this paper is based primarily on these first samples of pilot smart cities, and the sample cities are treated as follows in the selection process of the treatment and control groups: firstly, since the second and third batches of smart city pilot lists were successively announced after 2012, in order to ensure that the results of the subsequent empirical analysis in this paper include the net effect of the first batch of smart city pilot policy, the cities in the second and third batches of pilot lists are excluded, and these prefectural-level cities are not used as either the treatment group or the control group. Second, certain smart city pilots occur in a district or a county within a prefecture-level city, while the research level of this paper is a prefecture-level city; in order to avoid underestimating or overestimating the impacts of smart city pilot policy on green and high-quality development of a city, the prefecture-level city in which this type of pilot is located is excluded from the research sample. Finally, the balanced panel data of 156 prefecture-level cities are adopted for the evaluation of policy effects, of which 33 cities are treated and the remaining 123 cities are control, and the geographic distribution of the treated and control groups is shown in Table 1. In order to ensure the authenticity of the research results, this paper tries to prolong the time interval of the policy estimation as much as possible and determines the sample period as the period of 2006–2019, and some missing data are filled in by linear interpolation. The data come from *China Statistical Yearbook*, *China Urban Statistical Yearbook*, and statistical yearbooks of provinces (cities), and some missing data are filled in by linear interpolation; the descriptive statistics of the main variables are shown in Table 1.

Table 1. Variables and descriptive statistics.

Variables	Sample Size	Mean	Standard Deviation	Minimum	Maximum	Data Computation
Level of urban green high-quality development (h)	2184	0.235	0.064	0.062	0.787	
Financial development level (Y)	2184	0.842	0.545	0.181	9.622	Loan balance of financial institutions/regional GDP
Consumption demand (Z)	2184	0.367	0.112	0.001	1.013	Total retail sales of consumer goods/regional GDP
Opening-up level (G)	2184	0.016	0.019	0.001	0.199	Foreign investment actually used/regional GDP
Industrial structure development (U)	2184	0.899	0.509	0.188	4.946	Value added of the tertiary industry/value added of the secondary industry
Urbanization level (X)	2184	49.067	14.852	16.69	95.16	Urban resident population/total resident population
Financial and scientific investment (W)	2184	0.002	0.003	0.001	0.063	Science expenditure in the general budgetary expenditure/regional GDP

5. Results Analysis

In this paper, the smart city pilot is regarded as a quasi-natural experiment, and its policy effects on urban green and high-quality development are empirically assessed by a DID model. According to the established econometric model, it is empirically simulated by Stata 17.

5.1. Benchmark Regression Analysis

Model (1) reports the double-difference estimation results of a smart city pilot and urban green high-quality development when no control variables are added after controlling for time and city fixed effects, and the estimated coefficients are significantly positive at the 1% level, which means that the implementation of the smart city pilot policy significantly promotes the level of urban green high-quality development. In order to exclude the endogenous influence of other economic and social development variables on the results, five control variables related to the sustainable development of the city are added on the basis of model (1); model (2) is then constructed for further empirical testing, and the regression coefficient is still significantly positive at the level of 1%, which illustrates the positive effect of the policy implementation on the urban green and high-quality development. Therefore, H1 hypothesis is verified. The results are shown in Table 2.

Table 2. Policy effect assessment of smart city pilots.

Variables	(1)h	(2)h	(3)h
did	0.029 ***	0.035 ***	0.037 ***
	(8.93)	(13.15)	(4.78)
lnX		0.099 ***	0.238 ***
		(16.02)	(8.82)
Y		0.007 ***	0.062 ***
		(3.61)	(7.56)
Z		0.025 **	
		(2.31)	
U		0.041 ***	
		(16.28)	
G		−0.158 ***	−0.941 ***
		(−3.24)	(−5.43)
W			6.588 ***
			(6.19)
Constant	0.197 ***	−0.216 ***	−0.790 ***
	(189.34)	(−9.40)	(−7.49)
City fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Observations	1988	1988	1392
Number of id	142	142	92
R-squared	0.568	0.716	0.735

Note: Values in parentheses are standard errors; ** and *** are significant at the 5% and 1% levels, respectively.

5.2. Analysis Based on PSM-DID

Although model (2) proves the positive effect of smart city construction on urban green and high-quality development to a certain extent, the premise of model (2) is that the smart city pilot policy is a completely randomized quasi-natural experiment. As a matter of fact, when the state selects pilot smart cities, it inevitably takes into account factors such as regional location conditions, stage of economic development, level of industrial development, city size, etc. Some of these factors are introduced as control variables of the model, while the remaining ones are introduced as perturbation terms of the model because they are impossible to find out or are not measurable, resulting in a correlation between the explanatory variables and the perturbation terms, that is, the model has self-selection bias, which is prone to endogeneity problems. The existence of systematic differences means the estimation results of model (2) may overestimate the enhancement effect of policies on urban green and high-quality development; therefore, this paper further adopts PSM to solve the self-selection bias caused by observable variables and improve the robustness of empirical analysis.

In this paper, urbanization level (X), financial development level (Y), opening-up level (G), consumption demand (Z), industrial structure development (U), and financial and scientific investment (W) are selected to characterize the factors to be considered in the selection of pilot policies, and the PSM method is used to match each experimental group of cities in the model to the control group of cities that are similar to them in terms of their economic and social development to achieve an approximation of randomized experiments for smart city pilot policy. The logit function is used to calculate the propensity score (P-score) of the pilot smart cities to find suitable control group samples for the treatment group, and the balance test and the kernel density function plot are further used to analyze the balance of the variables before and after the matching; the results of the balance test are shown in Table 3.

Table 3. Ps-test results before and after matching.

Variables	Unmatched Matched	Mean		% Bias	% Reduction ∣Bias∣	t-Test		V(T)/ V(C)
		Treated	Control			t	P > ∣t∣	
lnX	U	4.094	3.8141	99.1		13.90	0.000	0.70 *
	M	4.094	4.1122	−6.4	93.5	−0.80	0.424	0.99
Y	U	1.0728	0.81346	46.6		6.94	0.000	0.99
	M	1.0728	1.0135	10.6	77.1	0.97	0.334	0.47 *
Z	U	0.37417	0.36953	4.3		0.62	0.538	0.81
	M	0.37417	0.37218	1.8	57.1	0.20	0.839	0.75 *
G	U	0.02453	0.01536	48.5		7.28	0.000	1.02
	M	0.02453	0.02492	−2.1	95.7	−0.19	0.852	0.46 *
U	U	0.87186	0.902	−7.0		−0.91	0.361	0.43 *
	M	0.87186	0.83048	9.6	−37.3	1.42	0.157	1.05
W	U	0.00386	0.00183	69.3		12.08	0.000	2.11 *
	M	0.00386	0.00331	18.7	73.0	1.71	0.888	0.79

Note: * is significant at the 10% level.

From Table 4, it can be found that the standardized deviation (%bias) of most covariates is less than 10%, which shows a better balancing effect. Meanwhile, the covariates of residents' consumption demand (Z) and industrial structure development (U) have no significant difference before and after matching, which means they do not meet the requirements of the balance assumption, so these two variables cannot be analyzed subsequently. On the other hand, the means of the four covariates of urbanization level (X), financial development level (Y), opening-up level (G), and financial, scientific, and technological investment (W) are significantly different from those of the treatment group before matching but not after matching, and the standardized deviation is reduced by more than 70% after matching, which means that they can be considered to support the use of the PSM-DID method for subsequent analysis. Thus, based on the PSM-DID model constructed by Equation (2), the impact of smart city construction on urban high-quality sustainable development is further examined. Model (3) in Table 3 reports the empirical results, which are basically consistent with the results of the baseline regression analysis, i.e., it can be argued that the implementation of the smart city pilot policy accelerates the process of high-quality urban ecological development at the 1% significance level, and hypothesis H1 is confirmed again. It can be seen that in terms of the current development stage of most cities in China, promoting smart city construction, highlighting the human factor in the application of modern digital information technology such as big data and the Internet of Things, and making room for the development of emerging industries with high technological content and green environmental protection will help cities to move towards the goal of high-quality, high-efficiency, green and sustainable development on the basis of a higher level of economic structure.

Table 4. Moderating effect test results of FSI.

Variable	(1) h	(1) h
did	0.033 ***	0.018 ***
	(12.36)	(4.94)
W	2.023 ***	1.362 ***
	(7.33)	(4.66)
didW		4.179 ***
		(6.37)

Table 4. *Cont.*

Variable	(1) h	(1) h
lnX	0.097 ***	0.098 ***
	(15.93)	(16.33)
Y	0.006 ***	0.006 ***
	(3.29)	(3.10)
Z	0.025 **	0.027 **
	(2.31)	(2.58)
U	0.042 ***	0.041 ***
	(16.63)	(16.49)
G	−0.156 ***	−0.158 ***
	(−3.23)	(−3.31)
Constant	−0.211 ***	−0.216 ***
	(−9.34)	(−9.64)
City fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	1988	1988
Number of id	142	142
R-squared	0.724	0.730

Note: Values in parentheses are standard errors; ** and *** are significant at the 5% and 1% levels, respectively.

5.3. Moderating Effect Test

By the PSM-DID model, the direct effect of smart city construction on urban green high-quality development is verified. Taking the FSI of local government as the regulating variable, regression analysis is carried out based on the moderating effect model constructed by Formula (3) in the previous chapter, and the results of the empirical test are shown in Table 4.

From the regression analysis results, it can be seen that the regression coefficients are significantly positive with the level of urban green and high-quality development as the explanatory variable and the government's FSI as the control variable in model (1). Model (2) is based on model (1); adding the cross-multiplier of smart city construction and FSI, the empirical results show that the regression coefficients are still significantly positive at a 1% significance level, and hypothesis H2 is confirmed. That is, the FSI level of local governments in the process of urban construction plays a positive moderating role in the promotion mechanism of smart city construction and urban green high-quality development. Further, the amount of the positive regulating effect of FSI is calculated, which shows its positive regulating role in the mechanism of smart city construction and urban high-quality development more clearly and intuitively in the form of a line graph. Figure 2 shows the regulating effect diagram of financial science and technology investment.

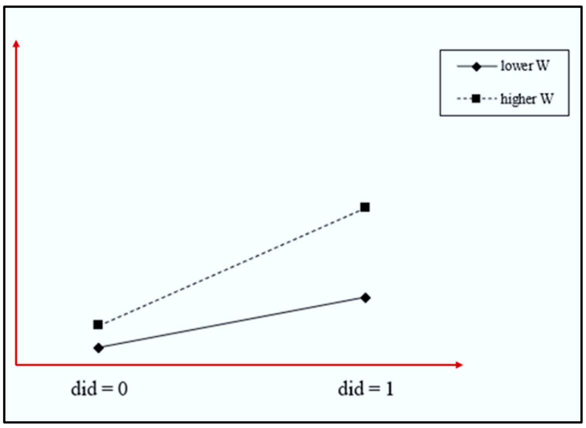

Figure 2. The moderating effect of financial investment of science and technology.

In Figure 2, the horizontal axis indicates the implementation of smart city pilot policy or not and the vertical axis indicates the difference between the high and low levels of urban green and high-quality development. Obviously, the promotion effect of smart city construction on urban high-quality and sustainable development is stronger under the high level of FSI than that of smart city construction on urban high-quality and sustainable development under the low level of FSI. The reason may be that the booming development of new technologies such as IoT, AI, cloud computing, and so on is the foundation of smart city construction, and the development of these technologies requires a lot of high-end scientific research, in which the government's FSI plays a supporting role. On the one hand, scientific and technological research and development activities may find it difficult to obtain the favor of social capital because of their long capital recovery period and short-term benefits; on the other hand, small- and medium-sized enterprises are often unable to afford the high cost of scientific and technological research and development. Therefore, FSI of the local government will positively regulate the role of smart city construction in promoting urban green and high-quality development. In addition, by increasing financial support for scientific research activities through capital subsidies, tax incentives, and policy inclination, the government can incentivize large-, medium-, and small-sized enterprises to actively increase their R&D investment, thus enhancing the level of urban innovation and promoting the urban economic development to find the second growth curve.

5.4. Robustness Tests

(1) Parallel trend test.

In this paper, the parallel trend test is used to verify whether the indicator variables of the treatment and control groups satisfy the parallel trend assumption before the policy is introduced. If there is some difference between the treatment group and the control group before the policy is enacted, then the results of the regression analysis cannot be interpreted as the net effect of the policy, i.e., it fails the robustness test. As shown by the time–trend plot (Figure 3), the left panel demonstrates the mean values of the results of the indicators over time for the experimental and control groups, and the right panel shows the predicted values of the indicators over time for the experimental and control groups based on the linear trends model. Before 2012, the trend and magnitude of changes in the level of urban green and high-quality development of the control group and the experimental group are generally the same; after 2012, the level of urban green and high-quality development of the experimental group rises by a larger margin than the level of urban green and high-quality development of the control group. From this, it can be preliminarily concluded that the experimental group and the control group satisfy the long-term trend assumption before the policy was enacted, and the difference in the trend line after the policy was enacted is caused by the implementation of the smart city pilot policy.

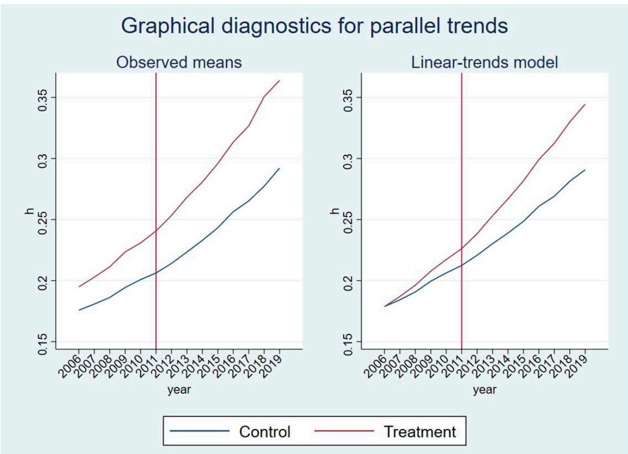

Figure 3. Time–trend graph.

Further, the significance of the cross-multiplication terms of the dummy variables of the experimental group and the time dummy variables is verified using the event study method to show the dynamic economic effects of the policy implementation in different years in a visual graphical manner. As shown in Figure 4, the coefficients of the interaction terms of the dummy variables of the pre-policy point in time and the dummy variables of the treatment group are not significantly different from 0 (the 95% confidence interval includes the value of 0), and the coefficients of the interaction terms of the post-policy point in time are significantly greater than 0. This indicates that there is no significant difference between the treatment group and the control group before the point in time of the policy, i.e., it fulfills the assumption of the parallel trend, that there is a significant positive effect after the policy implemented, and that the impacts of the policy have a certain degree of persistence and an expanding trend over time.

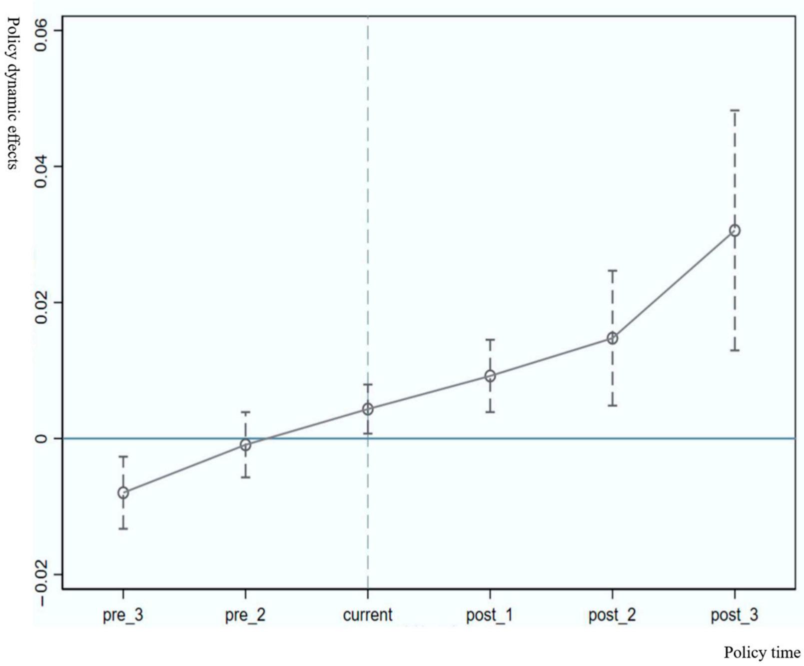

Figure 4. Dynamic effect graph.

(2) Transforming the treatment group.

Drawing on scholars such as Freudendal-Pedersen et al. and Zhang Jie and Li Qian-hui [23], the cities in the control group are randomly selected as the experimental group. The original experimental group is used as the control group sample, and the same DID method is applied to assess their policy effects. If the regression results do not present a significant positive effect, the previous empirical analysis is considered to provide strong evidence to illustrate the role of smart city construction on urban high-quality and sustainable development. As shown in Table 5, 24 cities in the control group sample are selected randomly as the experimental group. The test using the DID method shows that the coefficient of the interaction term is 0 and not significant. Thus, it is judged that the implementation of smart city pilot policy can play a positive role in urban green and high-quality development, and the empirical study is robust.

Table 5. Regression analysis.

Variables	h
did	0.000
	(0.03)
lnX	0.091 ***
	(14.15)
Y	0.006 ***
	(3.16)
Z	0.018
	(1.60)
U	0.043 ***
	(16.00)
G	−0.143 ***
	(−2.79)
Constant	−0.184 ***
	(−7.73)
City fixed effect	Yes
Year fixed effect	Yes
Observations	1988
Number of id	142
R-squared	0.689

Note: Values in parentheses are standard errors; *** is significant at the 1% level.

6. Conclusions

In this paper, 156 prefecture-level cities in China from 2006 to 2019 are selected as research samples, and a DID model based on the PSM method is constructed, while panel data of prefecture-level cities are utilized for regression analysis to empirically test. It is researched whether the implementation of smart city pilot policy has played a positive role in promoting urban green and high-quality development, as well as whether local government FSI has played a positive moderating role in the relationship between the two, and a robustness test is conducted on the above.

Firstly, there is a positive effect of smart city construction on urban green high-quality development.

Research in this paper explores the role and influence mechanism of smart city construction on urban green high-quality development in two dimensions: theoretical research and empirical analysis. In terms of theoretical research, smart city construction implies product innovation, technological innovation, market innovation, resource allocation innovation, and organizational innovation, which are regarded as the starting points of the urban innovation-driven development stage. As smart city construction continues to deepen with the support of innovative elements, the three effects of technological progress, configuration efficiency, and structural upgrading gradually appear. They promote the continuous improvement of social support functions, the continuous improvement of ecological environment effectiveness, and the continuous accumulation of positive development momentum, and the city is able to realize the vision of the intersection of green and high-quality development. In terms of empirical analysis, the promotion effect of smart city construction on urban high-quality development is verified.

Secondly, local governments' financial investment in science and technology enhances the positive impact of smart city construction on urban green and high-quality development.

Research in this paper explores the moderating role and influencing mechanism of FSI on the relationship between smart city construction and urban green high-quality development from both theoretical research and empirical analysis perspectives. Results show that local governments' FSI has a positive regulating effect on this development. Smart city construction is based on the principle of being government-led and market-driven, and the government plays a general leading role in smart city construction. Local financial expenditure, as an important means of government macro-control of social and economic development, affects the relationship between smart city construction and urban green high-quality development. Smart city construction cannot be separated from scientific and technological innovation, and scientific and technological innovation activities are characterized by a long payback period, high investment risks, and strong positive externalities, which require government leadership and intervention.

Certainly, there is a need for research to further develop in the discussion of causality between smart city construction and urban green and high-quality development. The validation of this study affirms the positive contribution of smart city construction to green and high-quality development, as well as the moderating influence of financial and scientific investment. As society and the economy continue to evolve, improvements in green and high-quality development may also generate a higher demand for new technologies and management models, which in turn will promote enhancements in smart city construction. As a new mode of urban development, smart cities are an important way to promote the speed and quality of new urbanization, stimulate the endogenous dynamics of economic growth, and improve urban resilience. Local governments should seize the development opportunity of smart city pilot policy, provide the necessary policy support and financial inclination for smart city construction, optimize the local economic structure, and transform the kinetic energy of urban development to help cities realize the intersection of green development and high-quality development moving forward.

This study may have certain limitations. Firstly, the time frame and scope of the research sample need further expansion. A larger and more diverse sample size would help explore the impact of smart city construction on urban green and high-quality development under different institutional and cultural backgrounds, thereby enhancing the scientific credibility of the study conclusions. Secondly, in terms of methodology, this study assumes a linear relationship between smart city construction and urban green and high-quality development. Future research could adopt non-linear regression models to further analyze their relationship. Additionally, a spatial econometric model could be used in future studies to conduct more in-depth investigations into the policy effects of smart city construction across different regions.

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